Applied Science Dept.

ADHESIVES AGE

MANUFACTURE, APPLICATION, TECHNOLOGY, RESEARCH AND MARKETING

JUNE, 1959

POLYSULFIDE SEALANTS—*Weatherproofing a Curtain Wall Skyscraper* **19**

SYNTHETIC ADHESIVES OUTLOOK—*A Survey of Present and Future Markets* **22**

METAL BOND DETERIORATION—*Adhesive Strength and High Temperatures* **27**

TYPES OF ADHESIVE BONDS—*An Explanation of Why Adhesives Adhere* **39**

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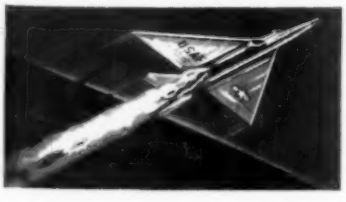

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HT-2	−65° to 350°F Continuous plus 2800°F Intermittent	Paste
HT-3	−65° to 550°F Continuous plus 3000°F Intermittent	Putty
HT-4	−65° to 500°F Continuous plus 1750°F Intermittent	Putty
HT-5	−80° to 600°F Continuous plus 2500°F Intermittent	Paste
HT-12	−65° to 300°F Continuous plus 1500°F Intermittent	Heavy dough-like
HT-13	−65° to 350°F Continuous plus 2800°F Intermittent	Heavy dough-like
HT-23	−60° to 350°F Continuous plus 1800°F Intermittent	Heavy dough-like

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About the Cover Photograph

Our staff photographer took this month's cover photograph at the construction site of New York's newest curtain wall skyscraper, the 52-story stainless steel and glass Union Carbide Building on Park Avenue. It shows the pressure application of a polysulfide seal immediately prior to the installation of a stainless steel mullion cap. For more information, turn to the article beginning on page 19.

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PP PALMERTON PUBLISHING CO., INC.

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RED STRIPE.....101-120 grams
RED STRIPE.....81-100 grams
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News about R&A SINCE 1913 **Adhesives**

FOR ALL METALS AND ALL PLASTICS

Odor-free "Mylar"/cello/poly adhesive won't shrink, curl or "worm"

TECHNICAL DATA ON

Bond*master*® L368

A synthetic rubber, solvent-dispersed, low-viscosity, versatile laminating adhesive for bonding a wide variety of films, foils, papers, and fabrics. Odor-free, colorless in a thin film, high color stability. Particularly recommended for flexible vacuum packaging of food products.

BOND CHARACTERISTICS

Completed laminations made with BONDMASTER L368 combine optimum bond strength with excellent resistance to worming and delamination.

APPLICATION

May be applied by engraved or knurled rolls as well as smooth rolls (both reverse and direct). Conventional techniques involve oven-drying at 180°-220°F for 30-60 seconds, then combining between squeeze rolls at speeds up to 200 feet per minute (polyethylene/cellophane and polyethylene/"Mylar" laminates).

OTHER SERIES "L" ADHESIVES

BONDMASTER L368 is but one of a series of BONDMASTER adhesives specifically formulated for such mass production lamination applications as: acetate-to-foil packaging; phase and layer insulation laminates; bottle cap liners; metallic yarns; barrier wraps; etc. Write for individual Data Sheets applying to your current laminating problems.

R&A SINCE 1913

RUBBER & ASBESTOS CORPORATION

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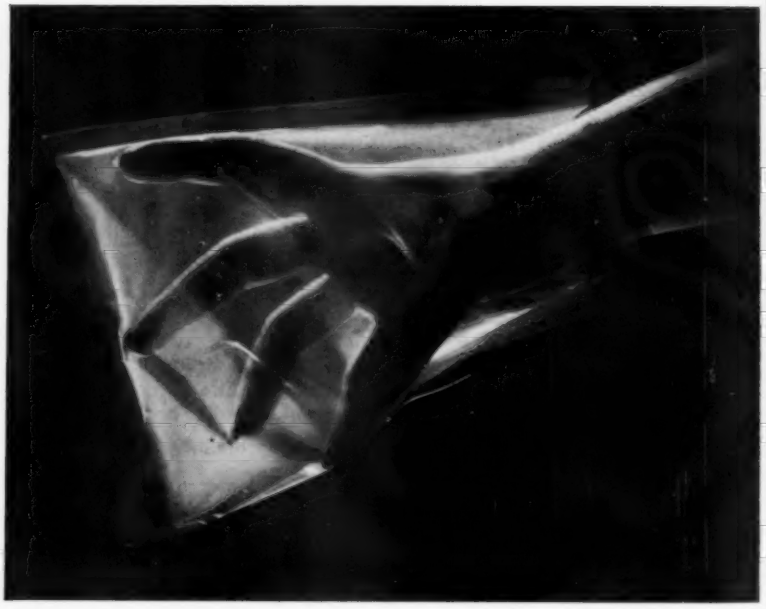
BLOOMFIELD, NEW JERSEY



Since this new, odor-free laminating adhesive was originally developed for flexible vacuum packaging applications, it was formulated to be color-free in a thin film and to maintain exceptional color stability. As a result, laminations made with BONDMASTER L368 have been widely used, with excellent results, to package cheeses and other "sensitive" food products.

Because it provides a good balance of solids and viscosity, it combines optimum bond strength with excellent resistance to "worming," "tunnelling," and delamination when laminates are subjected to high and low humidity and temperature cycles as well as to prolonged exposure in food freezers and refrigerators. In addition, users report complete elimination of shrinkage problems in cellophane/polyethylene-laminate heat-sealable bag manufacture.

MULTI-PURPOSE USE

BONDMASTER L368 offers outstanding production speed and savings in the mass production laminating of treated and untreated polyethylene film to cellophane (plain and printed); saran-coated cellophane; "Mylar" (plain and printed); and saran-coated "Mylar." It is also recommended for laminating aluminum foil and other flexible films, foils, papers, and fabrics.

WRITE FOR FURTHER DATA

Write for Technical Data Sheet detailing adhesive laydown, solids, viscosity range, etc. If you will describe your bonding problem in detail, we will be glad to send you a free evaluation sample as well.

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EDITORIAL

And What is *Your* Business?

In order to keep our readers abreast of all facets of adhesives manufacture, application, technology and sales, the editors of this publication, seeking to elicit editorial material suitable for publication, contact many manufacturers. Our efforts in this direction have revealed an interesting situation.

A month or so ago, we contacted a large manufacturer of paper end-products. We had been given to understand that this manufacturer was employing a new adhesives technique on his production line. It should be said that "secrecy" was not a factor involved. When we spoke with this manufacturer he expressed surprise at our interest. "Hell," he said, "we're not adhesives people, we're paper people!" This dialogue then took place between our editor and the manufacturer:

Editor: I know that you have a laboratory staff—do you employ any adhesives technicians?

Manufacturer: Certainly. We have two full-time adhesives chemists.

Editor: Do you compound your own adhesives, or do you purchase prepared mixes?

Manufacturer: At one time we purchased prepared mixes, but for the past few years we have compounded our own.

Editor: Do you use specific machinery and equipment for mixing and application?

Manufacturer: Sure. We have mixers with over 600-gallon capacity. We also use folder-gluers and what have you.

Editor: Are some of your employees engaged exclusively on the adhesives end of your manufacturing process?

Manufacturer: Sure.

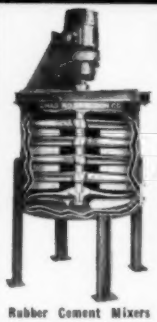
We needn't belabor the point any longer. Our editor managed to convince the manufacturer that he was indeed part of the adhesives industry. The situation detailed here has occurred several times. It would seem obvious that the furniture maker, the aircraft manufacturer, the corrugated box manufacturer, the bookbinder, etc., etc., are an integral part of the adhesives industry. Anyone who uses adhesives; who buys and sells adhesives; who uses adhesives machinery and equipment; who packages adhesives, is part of the industry.

You may be a paper manufacturer first—but adhesives may make your product possible. You may be a furniture manufacturer in the telephone book—you are an adhesives consumer to us.

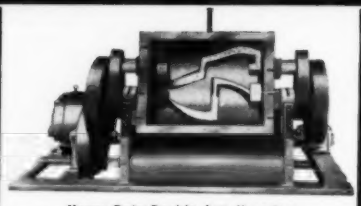
We believe that this journal can play an important role in your business for—to a greater or lesser degree—adhesives are everybody's business!

ADHESIVE PROCESSING MACHINERY

gives better results in less time!

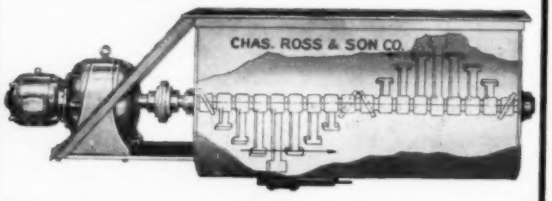


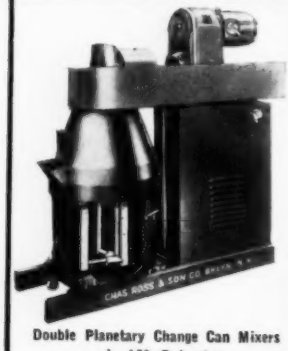
Rubber Cement Mixers
100 - 1000 Gal. sizes



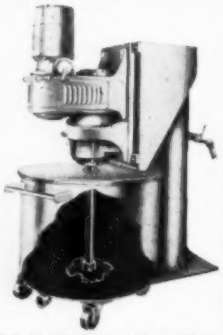
Heavy Duty Double Arm Kneaders
1 pint - 150 Gal. sizes

Horizontal Mixers
100 - 1000 Gal. sizes

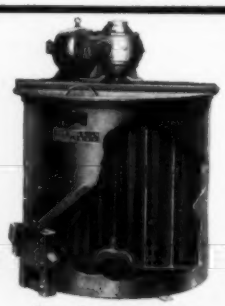




Double Planetary Change Can Mixers
1 - 150 Gal. sizes



High Speed Change Tank Mixers
80 - 250 Gal. sizes



Heavy Duty Paste Mixers
25 - 1000 Gal. sizes

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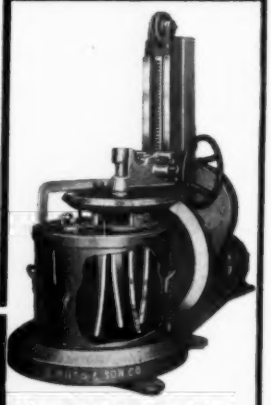

Heavy Duty Change Can Mixers
8 - 60 Gal. sizes

CHARLES ROSS & SON COMPANY, INC.

Dept. A1, 148-156 Classon Ave., Brooklyn 5, N.Y.

CONSULTANT'S CORNER

By Dr. Irving Skeist

Question: Our company is a subscriber to ADHESIVES AGE. Our products are various wooden shaped cases. We laminate sheets of veneers with vegetable glue and then form them under pressure and heat to cure and shape the cases.

Where the shaping of the wood takes place, there are always a tremendous amount of cracks which we have to fill by hand. Could you please tell us if there is an adhesive or special coating we can apply to the wood before forming it? Perhaps in this way we can reduce the amount of cracks.

Answer: Apparently you are exceeding the elastic limit of the wood by a considerable amount. Can you slice the veneers any thinner? The thinner the wood, the more flexing it will take.

I know of no adhesive or coating per se which will take care of your problem when applied to the wood before forming. However, you might try softening the wood with plasticizers.

Water is the cheapest plasticizer. Try steaming the veneer first. If this does not give adequate improvement, treat the wood with a humectant such as diethylene glycol. Remeber that cellophane, which is, after all, a regenerated wood product, must be plasticized with glycerine, glycol or some other humectant to avoid brittleness.

Q-110

Question: We cover an exposed upholstery nail line by a sewn, double welt, fabric covered strip. We have been using an ammonia-latex glue that sets up very quickly and without any other pressure than that applied by the operator's thumb as he passes the welted material across the nail line.

The glue is applied by hand roller to the back of the welt. It has provided an entirely satisfactory

Readers who would like to contribute their own experience with problems similar to those discussed in Dr. Skeist's column are invited to write to ADHESIVES AGE, *101 West 31st Street, New York 1, New York. Please refer to the code number given at the end of each question and answer group.*

CONSULTANT'S CORNER

bond, but after a period of time it turns a brownish yellow. In some cases it seems to come out of solution and run down to stain and discolor the upholstery fabric.

We would like your recommendations on an adhesive that will set up quickly, develop immediate holding strength, and nevertheless be resistant to fading or becoming tacky in time.

Answer: Your troubles may emanate from the nails rather than the glue itself. While it may seem extravagant to use coated upholstery nails where they don't show, I should urge you to go to the coated varieties to avoid rusting.

An alternate solution is to use a vegetable glue containing a rust inhibitor of the amine type. Examples of these are triethanolamine oleate or Hercules' Rosin Amine D.

Q-111

Question: We want to bond tenite butyrate granules to sheet glass. The glass would be set on a table and the adhesive spread by brush. The adhesive must be water-resistant, transparent, colorless—or as close to it as possible—have a consistency of honey or thereabouts, and have a curing time of 20 minutes to a day without heating or pressure. It must also be fully resistant to any destructive influence of prolonged exposure to sunlight.

Answer: A vinyl butyral resin might fulfill your requirements. These resins, made by two major manufacturers, are transparent and colorless. They can be made to have a honey-like viscosity or any other desired viscosity through selection of resin and proportion of solvent. The resins vary in molecular weight, and those having the highest molecular weight have the highest viscosity. No curing is involved; rather they harden by evaporation of solvents. No heating or pressure is necessary in the case of *unmodified* butyral. Resistance to ultra-violet is good.

One of the desirable attributes of the vinyl butyral is its excellent adhesion to many surfaces including glass.

The water-resistance of the vinyl butyral is not of the best, however. If it turns out that water-resistance is inadequate, it may be necessary to add a small proportion of a cross-linking agent. If the vinyl butyral turns out to have inadequate water-resistance, even when compounded, it will be necessary to try another type of adhesive. Cellulose acetate butyrate may itself be a satisfactory base material, although its adhesive qualities are not comparable to those of vinyl butyral. Cellulose acetate butyrate, like vinyl butyral, has excellent ultra-violet resistance. A pyroxylin dope may provide better adhesion to the glass, and may be satisfactory in its adhesion to the butyrate; but in this case, the resistance to sunlight will be poor.

Q-112

Dr. Skeist is associated with Skeist & Schwarz Laboratories, Inc., 89 Lincoln Park, Newark 2, N.J. He is the author of the recently published book, "Epoxy Resins."

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new adhesives

AND ADHESIVE PRODUCTS

Packaging Adhesives

Although the Solu-Rez series of polyvinyl acetate resin adhesives was primarily developed for use in carton sealing and forming, it offers interesting possibilities for use in tube winding, folding box manufacture and sealing multiwall bags. The combination of low viscosity and fast setting speed allows the use of Solu-Rez on a wide variety of sealing equipment, including those types that require the adhesive to be pumped. This versatility eliminates the necessity for storing many different adhesives. Because there is no viscosity build-up, cleaning operations can in many cases be cut to once a week. Any filming caused by standing is redissolvable in the adhesive itself. Solu-Rez can be cleaned from machine parts and the glue box with water. *Morningstar-Paisley, Inc.* ***P-116***

Room Temperature Adhesive

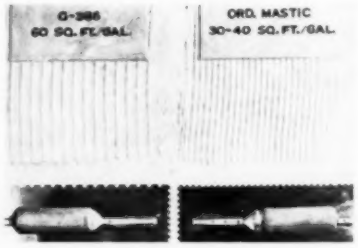
When used with Catalyst 1684, Plyophen 1880 will produce a satisfactory bond at temperatures as low as 70°F. by merely applying clamp pressure for 16 to 24 hours. At temperatures of 100°F. a satisfactory bond is obtained in as little as four hours. The modified resorcinol resin meets Military Specification MIL-A-397-B as Type II, Grade D, Class 1 Adhesive. It can also be used in the production of exterior grade plywood using a cold press. Pressures of 100-200 psi may be used on softwoods and 200 psi on hardwoods. Equipment may be cleaned with warm or cold water. Hot water is not desirable as it tends to set the adhesive. *Reichhold Chemicals, Inc.* ***P-117***

Insulating Tape

Insultape consists of a urethane foam bonded to a tough water-resistant transparent film coated with a transparent pressure-sensitive adhesive. It is available in widths up to 36 inches and in ⅛-, ¼-, and ½-inch thicknesses. Industrial applications include insulating, vibration dampening, protective packaging, and dust- and moisture-proofing. *Arno Adhesive Tapes, Inc.* ***P-118***

Tile Adhesive

Up to 12 hours working time and substantially increased job life are said to be offered by a new plastic and tile adhesive called G-386. The white rubber-based composition re-



mains permanently elastic and does not oxidize, bleed from joints, discolor, or become hard and brittle with age, the manufacturer points out. Designed for installing polystyrene wall tiles or extruded polystyrene panels to smooth, clean wall surfaces, G-386 reacts chemically with the back of the plastic surface after prolonged contact to form an inseparable bond. It will maintain a bond with a plastic tile through any range of temperature that the tile will withstand without distortion. A gallon will cover approximately 60 square feet. No priming is required on white coated plaster or plasterboard. Application is by notched trowel. *Armstrong Cork Co.* ***P-119***

Flocking Adhesive

Although it has a non-inflammable water base, Self-Stix has excellent water resistant qualities, making it feasible to use even in humid locations. It can also be used as a dry flocking adhesive. Designs may be applied with a brush, and when dry, flock, tinsel, glitter, or other decorative materials can be placed in contact with the design to which they will immediately adhere.

Since Self-Stix need be applied to only one surface, and adhesion is made when dry, even the finest and most delicate fabrics can be adhered without fear of adhesive penetration. It may be easily applied by brush, roller coater or spray. *Adhesive Products Corp.* ***P-120***

Adhesive-Finished Rayon

An adhesive-finished high tenacity rayon yarn, Super Cordura Type 272-F was developed for reinforcing mechanical rubber goods. Capable of being processed on conventional industrial weaving equipment, the product embodies the advantages of adhesion without the necessity for fabric dipping. In trade testing, Type 272-F has given adhesion values greater than 20 pounds per inch in many types of rubber stocks. The high tenacity rayon yarn will retain 40 per cent greater adhesion when wet as compared with conventional RFL-dipped rayon, according to the manufacturer. The product has a good shelf life, with no change in adhesion reported following ten months of storage. *Textile Fibers Dept., E. I. du Pont de Nemours & Co., Inc.* ***P-121***

Ceramic Tile Adhesive

Water-resistant and providing high strength when dry, CTA-20 can be used to bond ceramic wall tile over gypsum wallboard, finish coat plaster, painted plaster, plywood, concrete or almost any sound, smooth surface. Because it has an open bonding time of up to four hours, depending on temperature and humidity conditions, large sections of wall surface can be spread with adhesive at one time. CTA-20 provides shear strength in excess of 1500

pounds per tile at room temperature and over 500 pounds per tile at 125°F. Its water resistance makes it available for installing tile in areas of high heat and humidity. Application is with a notched scraper. One gallon of adhesive covers approximately 60 square feet of surface. *Adhesives, Coatings and Sealers Division, Minnesota Mining & Mfg. Co.* ***P-122***

Silicone Rubber Adhesive

Chemlok 607 is an adhesive for bonding a wide variety of unvulcanized compounds of silicone rubbers, Viton A, Hypalon and urethane elastomers to metals, synthetic fabrics, glass, plastics and other materials. The bond formed is said to be stronger than the elastomer at temperatures as high as 500°F. It is resistant to any destructive environmental condition that the elastomer

itself will withstand. The colorless adhesive is applied at room temperature by dipping, brushing or spraying. It air dries to a non-tacky surface in 10-20 minutes and requires no treatment prior to bonding. Bonds are formed at vulcanizing temperatures recommended for each elastomer by its manufacturer. High temperature postcure treatments for silicone rubber and Viton A can be used without weakening the bond. *Special Products Div., Lord Mfg. Co.* **P-123**

Contact Cement

An all-purpose water-base adhesive, Kwik Latex Contact Cement is said to combine the strength and durability of solvent type adhesives with the economy of latex cements. It is self-vulcanizing and the manufacturer points out that it actually becomes stronger with age. A long open time makes timing less critical. Application is by brush, roller, trowel or coating machine. Both surfaces are covered and allowed to dry before being placed together to form a strong, permanent bond. No heat or pressure are required. Because it is water-soluble, Kwik may be thinned with water and sprayed. This same quality makes it easy to clean cementing equipment. Kwik is recommended for cementing plastic surfaces. It will also bond steel to wood; plastic to leather, rubber, fabric, plaster, concrete and aluminum. Available in pint, quart, gallon, five-gallon and 55-gallon quantities. *Adhesive Products Corp.* **P-124**

Patching Compound

Ready for light traffic in four to six hours, P-D-Q Floor, a quick drying patching compound, bonds securely to concrete, brick, stone, wood, steel and glass block. It may be used indoors or outdoors and is said to combine the best elements of epoxy resin with other corrosion resistant ingredients to provide an extremely strong and long wearing surface offering protection against all acids, alkalies and oils. It will not chip or crack under the pressure of steel wheels carrying heavy loads, and it may be given a permanent non-slip finish where wet floors or metal surfaces present an accident hazard. Application is directly to any clean surface. A 50-lb package will cover 50 square feet with a ⅛-inch surface. P-D-Q is said to aid in preventing the formation of mold and mildew. *Maintenance Engineering Co.* **P-125**

Coating Resin

Numerous advantages for multicolor paints—as well as for colored aluminum and one-color coatings—are said to be available with a new resin called Marbon 1100 TMV. It requires only lower-priced petroleum solvents, and multicolor paint can be formulated with conventional equipment. Because of its low odor level, 1100 TMV based paints are especially desirable where odor is a major problem. Paints made with this resin are non-penetrating, washable, do not require a special undercoat and are resistant to alkalies, mild chemicals, salt water, abrasion, fumes and mildew. Features include outstanding stability in conventional cans and glass containers with no skinning and minimum settling. The vehicle's antistatic properties insure a product with the advantage of less dirt adherence. *Marbon Chemical Division, Borg-Warner Corp.* **P-126**

Self-Adhesive Plastic

Available in yard widths, Con-Tact Top is a new self-adhesive vinyl plastic made with Monsanto's Ultron. Its protective paper backing has three strip lines for quick and easy peeling. No experience, tools, water or paste are needed to apply it. After the paper backing is removed, the material is finger-pressed onto the surface to be decorated. It sticks to almost any dry, clean, dust-free surface including plaster, wood, metal and glass. *Cohn-Hall-Marx Co.* **P-127**

Pressure-Sensitive Adhesives

Applied as a 50 per cent solids formulation from water emulsions, Multibond adhesives are said to be permanently pressure sensitive. They will adhere to a wide variety of surfaces and can be stripped clean from most adhered objects. Application of these adhesives is by roller, brush, or spreader. Grades of Multibond are available for use with cellophane, ceramics, cloth, glass, leather, metals, Mylar, polyethylene (treated or extruded), polystyrene, polyurethane, polyvinyl chloride, rubber, Saran, Teflon, and wax coated board. These adhesives can also be used in wet operations. *Franklin Glue Co.* **P-128**

Neoprene Cement

Any combination of rubber, leather, wood, cork, glass, metal, plaster, paper, concrete, ceramics, celluloid and plastic other than vinyl can be bonded with Barge All-Purpose Cement, states the manufacturer. The product is also suitable for sealing water or gasoline tanks and lines. It has been used industrially by shoe and pocketbook manufacturers, glaziers, and cabinet makers. Supplies are available in sizes ranging from ¾-ounce tubes to 54-gallon drums. *Barge Cement Mfg. Co.* **P-129**

Spray-On Adhesive

Typical applications for Quick-Stick are: pasting up advertising artwork and type, mounting photo-

graphs, tacking notes and clippings to bulletin boards, etc. Colorless, odorless and non-toxic, this pressure-sensitive adhesive comes in a pressurized spray can. It can be used to hold any smooth surface to any other smooth surface, states the manufacturer. Materials to which it is applied may be removed and replaced on different surfaces many times without losing their adhesive coating. *Hudson Photographic Industries, Inc.* **P-130**

letters to the editor

Dear Sir:

The sealant gun pictured and mentioned in the article entitled "How to Select Curtain Wall Caulking Sealants" in the February, 1959, issue of ADHESIVES AGE is not one of those manufactured by Pyles Industries, Inc., but rather is manufactured by Semco Research, Inc., of Inglewood, California, and is now distributed by Semco Sales & Service, Inc., of the same city.

For several years, Pyles Industries, Inc., did distribute the sealant gun under an exclusive contract agreement with Semco Research, Inc., but this contract was terminated in 1958 and the gun in question on which U.S. Patent No. 2,838,210 was granted and assigned to Semco Research, Inc. is now distributed only by Semco Sales & Service, Inc. Pyles Industries, Inc. never did and does not now manufacture the particular gun mentioned.

This article also mentioned on page 36 several manufacturers of proportioning mixers. We wish to point out that the Dasher type proportioning mixers which are the subject of U. S. Patent No. 2,859,017 granted to Semco Research, Inc. were developed by and have always been manufactured by Semco Research, Inc. The latter also manufactures continuous type rotary mixers.

S. C. YOCUM
Semco Research, Inc.
Inglewood, Calif.

UBS Builds New Unit

UBS Chemical Corp., Cambridge, Mass., has begun the construction of a pilot plant and laboratory in Marlboro, Mass., which is scheduled for completion in June. The new buildings, to be settled on part of an 18 acre site located in the Massachusetts Industrial Center, will house a polymer development laboratory and a small scale production plant containing a multiple number of reactors and storage facilities. Designed to increase the pace of new product development, the Marlboro installation is expected to provide new equipment and improved laboratory facilities for UBS. However, major production will continue at the company's home plant in Cambridge.

The new Marlboro plant marks another step forward in an expansion program which was the end result of doubled sales between 1955 and 1957, UBS states. A new polymer plant was completed last January in Lemont, Ill., and is now in operation. UBS also has regional sales offices and warehouse facilities throughout the United States and Canada. Founded in 1903, the company is a manufacturer of polymer emulsions used by the floor finish, leather, paper and other industries. Other products include industrial adhesives, coatings and finishes for the shoe industry, fabric backings, etc.

Corn Products Earnings

Corn Products Co., New York, N.Y., reports that the company had its best year ever in 1958 with worldwide earnings amounting to $33,753,-068, equal to $3.00 per share, compared with $32,680,001, equal to $2.88 per share, for 1957. Worldwide sales were $649,978,446, compared with $612,279,304 for 1957. According to the company, 1958 saw important gains scored in industrial as well as consumer products. Corn Products' industrial business continues to account for a major share of its over all sales volume, the company reports. New lines of starch and dextrine products for the adhesive, paper and textile trades were successfully introduced, the company claims.

Named Representative

William A. Barnwell Jr., has been named a chemical sales representative for the Chemical Machinery Division of Baker Perkins Inc., Saginaw, Mich. He is a graduate of Louisiana Polytechnic Institute and formerly was a chemical engineer with Dow Chemical Co. in Freeport, Texas. He is a member of professional organizations such as the American Institute of Chemical Engineers and the American Chemical Society.

Milton C. Coon, Jr.

Named BRI Director

Milton C. Coon, Jr., has been appointed executive director of the Building Research Institute, succeeding William H. Scheick, who resigned last September. Mr. Coon, who has been serving as acting executive director since September, and also as secretary of the Institute, has a background of experience in building industry organizational work, having most recently been associated with the Tile Contractors Association of America. He has been on the BRI staff since September 1957, in charge of business administration, membership promotion and maintenance, physical arrangements for BRI meetings, etc., and in this capacity has been largely responsible for a substantial growth in BRI membership during the past 18 months.

Battelle Studies Odors

Battelle Memorial Institute, Columbus, Ohio, has announced that its scientists are investigating the relation between physical properties of substances and their effect on the human sense of smell. The research is being done for the Quartermaster Food and Container Institute for the Armed Forces, a unit of the Quartermaster Corps' Research and Engineering Command. The Battelle study is based on 30 odorous substances which were among odorants selected to represent a wide range of typical scents by Quartermaster Corps scientists in previous research. Battelle researchers sit in a closed "smelling booth," sniff odorants at 30 second intervals, and report a description of each odor. The reported characteristics of the odors are then studied in relation to six physical properties of the odorant.

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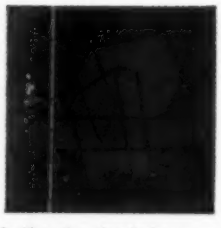

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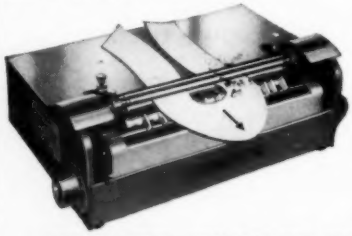

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capitol cues

A STEEL STRIKE STILL CAN'T BE RULED OUT this Summer, despite all the pressure being brought to bear on both sides by the President and Congress. The union is asking for a big package and says it won't take less than its members need. The companies don't want to be criticized for yielding without a fight. So officials see a deadlock and a strike lasting four to six weeks.

As a result of a strike, the union probably will get a hike in pay of about 10¢ per hour, plus fringe increases for such things as pensions, health insurance, etc. The new contract may run for three years. And despite Eisenhower's pressure, the mills can't absorb the added cost. Prices will rise 2-5%.

If a strike does begin early in July, steel in users' hands will total about 20 million tons, up 8 million since the first of the year. But that's not enough to carry most users past a four-to-six week strike. Some buyers are finding it hard to get the supplies they want this Spring. Shortages of transportation facilities have added to the difficulties.

THERE HAVE BEEN BIG PRODUCTIVITY GAINS in manufacturing in recent months, according to unpublished calculations of some government agencies. Output per manhour in the first quarter of this year was 7% greater than in the same period of 1958. (That's for all workers; for production workers, alone, the rise was 6%—meaning more line people than overhead employees were put on to handle extra business.) Economists say that increases of this magnitude are entirely normal for the first year of a business upturn.

Rising productivity will be a big issue in steel negotiations and other collective bargaining this year. The recent gains will get the spotlight even though increases will be smaller later on, as industry moves back closer to full capacity.

A NEW, ALL-OUT BOOM IN BUSINESS BY YEAR-END is being predicted by some economists. Thus far, this is merely a minority view; most experts don't see anything but a slow, steady rise in activity. The optimistic analysts are impressed with the way business is picking up all along the line. They don't believe that a steel strike, if it comes, would slow business down very much.

The boom-minded experts look for total output of services and goods to reach a $500 billion-a-year rate by the end of 1959—a gain of 5%. (It's now $470 billion-plus, 4% over the pre-recession peak of mid-1957.) For this target to be reached, there'll have to be big increases in inventories, in spending for new plant capacity, in consumer spending—and in prices.

Most economists in business and government expect business to fall $10 or $15 billion short of the half-trillion-dollar mark by year-end. While they look for steady upward gains in business, they don't expect a new boom before '60 or '61.

CANADA'S BUSINESS RECOVERY IS SLOWER than the upturn in the U.S. Normally, the cycle for our northern neighbor follows ours pretty closely. Its economy is tied to ours because we're its best customer—and by far. But this cycle is different because we are taking less of its oil, metals, and farm products—and these are the mainstays of the Canadians' economy.

•Industrial output is up 4-5% from the low, against 14% here.
•Employment has gained 2-3%, a little less than in the U.S.
Despite lags, Canada's economy will reach new highs in 1959.

A BOOST OF 4% TO 5% IN LUMBER PRICES is likely this Summer. Demand is strong, reflecting high rates of home-building; and dealers are trying to build up stocks. Meanwhile, lumber supplies are tightening. Some large mills are telling customers there will be delays in delivery. Small mills are feeling a pinch on logs. Bad weather slowed logging in many sections. The higher lumber prices, in turn, will force up the prices of new houses.

A TIGHTER REIN ON DEFENSE PROFITS OF SUBCONTRACTORS is on the way. Prime contractors will soon be under pressure from the Pentagon to see if they can cut back on the margins allowed their suppliers. The Pentagon is finding it more difficult to fit procurement costs into the Budget. And a committee of Congress is pushing the big contractors to take a searching look at suppliers' bills. Despite all of the talk, however, there probably won't be a uniform limit on margins. Pressure will be applied case by case.

The Senate Small Business Committee, at the same time, wants to figure out a way to force the prime defense contractors to give more work to small subcontractors. The share now going to smalls is down to 17.4% of all subcontracts, from 21% in '57.

WHAT BUSINESS RECORDS TO KEEP—AND FOR HOW LONG? This is a question that always arises after the figuring is finished and tax returns are filed. But it also plagues business at all seasons as required paperwork multiplies. Yet papers that have outlived need only fill space and create fire hazards.

Checks with government agencies reveal these guidelines:
•State and federal tax forms—Keep your returns for 6 years.
•Canceled checks—Hold for at least 6 years, 10 if possible.
•Payroll records—Keep 3 years; hold pension data permanently.
•Audits, ledgers, stock transfers—Keep these permanently.
•Shipping, billing, and job tickets—Destroy after 2 years.

IF YOU'RE LOOKING FOR A HIGH YIELD on an investment, you might well consider municipal bonds. With yields on stocks now so low, the tax exempt income of municipals can be attractive for middle-income investors. Though nominal interest rates only range from 3% to 4%, an investor in the $20,000 bracket will get as much as from a taxable security paying 6½% or even more. For people with higher incomes, the after-tax yields are even greater.

THIS WILL BE A BIG YEAR FOR SPORT FISHING, say government experts. The fish supply will be the best ever—trout, bass, and catfish, especially. Best spots will include coast waters, the Tennessee and Cumberland valleys, and the Alabama lakes. Catches may not be good in the drought-hit sections. Fishermen will spend nearly $3 billion for transport, tackle, and licenses.

● Housewives are demanding that more suitable adhesives be used on labels attached to housewares. The German press has published several complaints by housewives regarding these adhesives. The general view is epitomized in the May issue of *Good Housekeeping*. One woman wrote: "Here's a situation that I think is a perfect shame! We have recently bought a new house in which the stove and the wall oven are part stainless steel and part brushed aluminum. On each were gummed stickers, and when I tried to remove them, off came the paper but not the gum. Well, we tried everything—soaked it, scraped it, rubbed it. Finally, it was gone, but now there are squares of a different color where the gum was! The other day, I bought a percolator. Same thing: gummed label with the trademark. Same trouble. My mother had it with her new top-of-stove potato baker. She couldn't get the gum off, and when she used the baker, she baked on a permanent black stain."

Charlotte Montgomery, columnist for *Good Housekeeping*, emphasizes that with all the good new methods of sticking on labels, experiences like these are inexcusable. Yet, she points out that she hears the same sad story about black-gummed labels on sheets and table linens, mirrors, many plastics, and lighting fixtures. Also, she emphasizes that quality items are often the worst offenders.

There are about 1,500 American manufacturers who produce a variety of house-furnishing items. It might be an excellent idea for an enterprising factory to do some research and to approach the house-furnishing industry with an offer of suitable adhesives which will satisfy the most dainty and most exacting housewives.

● The development of the Soviet Russian chemical industry was planned during a recent conference of the Central Committee. From 1959 to 1965, the output of the synthetic rubber industry should be increased 3.4 times; the output of chemical fibers 4.6 times; and the output of plastics and synthetic rubbers 8 times. Construction of new and expansion of existing factories has been envisaged.

According to calculations of the State Planning Commission (GOSPLAN SSSR), in 1965, the production of synthetic rubber should be 250 per cent higher than it was in 1958, and car tire production should be increased by 200 per cent. Similar plans are laid down for the shoe industry. Improvements in the quality of cords and in chemical fibers are recommended. New factories for the manufacture of hydrolized alcohol and for synthetic alcohol from ethylene have already been constructed.

Other topics considered were the direct synthesis of butadiene from butane or butylene and possibilities of preparing butadiene, isoprene, chloroprene and other valuable monomers from petroleum.

● On Friday, April 17, the London Sections of the Institution of the Rubber Industry and the Plastics Institute held a one-day conference on "Adhesion." The program dealt with the following topics: "Physical Aspects of Adhesion"; "Surface Chemistry of Adhesion"; "Synthetic Melt Adhesives and their Applications." In the afternoon, the following papers were delivered: "The Assessment of Bond Quality in Glued Wood Joints" and "The Relation of Physical Testing to the Uses of Pressure Sensitive Adhesives."

● The German trade press emphasizes that in Stuttgart, which is located in southern Germany, there are many more jobs available than there are working men, stating that there is a ratio of ten job openings to one applicant According to the official statistics, there are many jobs open for specialists like mechanics, toolmakers, and workers in the chemical industry. There are also all kinds of openings for office help, and technical and administrative managers. In every one of these categories, there are at least two openings for each applicant. The employment offices emphasize that it is impossible to fill the demand of many industries and offices.

The tremendous upswing of the national economy in Germany has created this situation and it is indicated that there will be continuous growth of the domestic economy and also increased German exports.

● The Red Chinese chemical industry is expanding. According to very reliable reports, one center of the Red China industry is located in Shanghai and the surrounding vicinity. More than 960 chemical factories are located there already and the construction of 50 additional factories has been contemplated. Some of these factories are presently under construction. About 40 per cent of Red China pharmaceuticals are manufactured in Shanghai. In Peking, Tientsin and Nanking, more chemical factories are located, some of which manufacture sulfuric acid on a large scale.

Another chemical production center is located in Harbin, Manchuria, where more than 30 new factories have gone on stream. In this center, synthetic rubber is manufactured at a rate of 8,000 tons per year and 2,000 tons of plastics are produced annually. By the end of 1962, the number of chemical factories in Harbin is expected to reach 65 establishments.

According to the Red Chinese press, the production of chemical goods has been increased by more than 50 per cent compared with 1958. In November, 1958, a new factory went on stream in Peking which manufactures synthetic rubber. The raw material utilized are potatoes, which are now available in great numbers after an excellent harvest. The potatoes are transformed in butyl alcohol and acetone. The Chinese indicate that they need 30 tons of potatoes in order to manufacture one ton of synthetic rubber.

On the Continent

Red China is now trying to satisfy the domestic demand for soda ash, all kinds of dyes, drugs and insecticides and also plans to increase production to such an extent that considerable quantities of these chemicals may be exported. For this reason Red China is expected to become a competitor of many countries on the world market.

• A patent covering an adhesive which is especially suitable for bonding footwear soles has been granted to the German firm, Tivoli-Werke A. G. According to the patent, the adhesive is made by dissolving natural rubber in a strong solvent for rubber and then adding S-BR dissolved in a polymerizable monomer, preferably styrene. This adhesive is particularly suitable when at least one of the surfaces to be bonded consists of vulcanized or unvulcanized natural rubber.

A film of the adhesive containing styrene is applied to a rubber surface. When the solvent for the rubber evaporates, the styrene initiates a cross-linking action between the contacting surfaces. This takes place without the use of a polymerization catalyst. Resins, cyclized rubber and/or chlorinated rubber may be incorporated in the adhesive.

• The Continental press is very enthusiastic about American accomplishments regarding adhesives. Their opinion is that the United States is going to glue everything which was previously nailed, screwed, riveted or welded together. They also believe that America will eventually build cars, ships, machines and all kinds of installations utilizing only adhesives.

• The use of waste in the rubber industry is discussed in an article published in the Soviet Russian trade paper *Rubber and Resins*. Waste materials of the rubber and tire industry cannot generally be re-used. However, it has been found that these wastes can be used as roofing materials, which are easily dyed and which are said to be more stable than asphalt roofing paper or rubberoid.

Methods for utilizing this waste material by the factory, Krasnyy treugol'nik, were described. This factory produces corrugated textile-rubber sheets which are 44 inches long, 20 inches wide and about ½ inch thick. During one shift, about 90 sheets can be finished on a single press at a cost of about 3 rubles per sheet (30¢, according to the tourist rate of exchange). Output of 25,000 sheets, i.e. more than 135,000 square feet of roofing, is planned for this year.

It is very significant that the Soviet Russian trade paper admits that only 90 sheets can be finished on a single press, presumably in a shift of eight hours. We are sure that this output is far below the American standard.

• A Norwegian firm, A/S Askim Gummivarefabrik, has signed a contract with the Bata Shoe Co. of Canada for the production, under license, of Bata plastic footwear. Machinery required to produce this product line will be shipped from Canada this year.

• A compliment has been paid to our sister publication, *Rubber Age*. The International trade press quite often refers to *Rubber Age* and also to ADHESIVES AGE. It was flattering to read in the June issue of the Soviet Russian trade paper *Rubber and Resins*, that they used one article which had been published in *Rubber Age* in 1957 under the headline "Vulcanization of Tires Without Curing Bags."

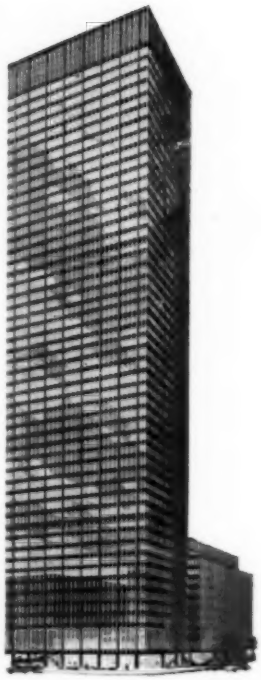
• R. T. Briscoe (Ghana) Ltd., and the East Asiatic Co. of Copenhagen have established a 2000 acre rubber plantation at Dixcove. The Ghana government has agreed in principle to participate. The first planting of 600 acres was made with seedlings from Liberia.

• *Rubber Journal and International Plastics* describes a patent on reinforced polythene articles which has been granted to Imperial Chemical Industries, Ltd. According to this patent, a reinforced polythene article is made by coating a metal reinforcement with a thin layer of polythene. The layer is oxidized by baking it at a temperature above its melting point. The coated metal reinforcement is placed in a mold with pieces of polythene and then molten polythene is injected into the mold to surround the reinforcement and to fuse the coating on the reinforcement with the pieces of polythene. By this process, the reinforcement is firmly bonded to the polythene and may be completely embedded in it. A polythene sieve reinforced with a steel wire gauze is cited as one of the products made by this process.

• *Chemische Rundschau*, which is published in Solothurn, Switzerland, discusses the importance of adhesives in its issue of March 15, 1959. It is emphasized that adhesives made from synthetic resins are used on a very wide scale. At the start, it was necessary to cure the adhesives, but now, in view of the fact that new methods—which probably utilize epoxies—have been developed, it is no longer necessary to cure the adhesives. They harden when exposed to air. As a result of this technological progress, a bridge was constructed with adhesives bonding the entire bridge together. Allegedly, this bridge has been in use for more than 2½ years and has been able to withstand all stresses and loads.

• The Plastics Institute recently held a two-day conference on "Polymeric Progress" at the William Beveridge Hall of London University. Proceedings during the first day of the conference, were opened with a paper entitled "New Polymers: New Problems," which was presented by Professor H. Mark of the Polytechnic Institute of Brooklyn, Brooklyn, N. Y. The remainder of the first day was devoted to "Materials," while the second day was concerned with "Methods—Present and Future Methods of Polymerization." Contributions were made by leading authorities from the United States, Germany, Italy and the United Kingdom.

STAFF REPORT



Polysulfide Sealants in Curtain Wall Construction

More than 5000 pounds of polysulfide materials will be used to seal the joints of 19 miles of stainless steel mullions to be used in New York's newest skyscraper, the 52-story steel and glass home of the Union Carbide Corporation.

An estimated 5,000 pounds of polysulfide sealant will be used to seal the horizontal mullion joints on the 52-story glass and stainless steel curtain wall structure now being erected on New York's Park Avenue by Union Carbide Corp. When completed in 1960, the deluxe office building will be the tallest on the avenue and the highest to be topped out in New York in the last 25 years.

The large scale sealing job, being handled by The Grenadier Corp., New York, N.Y., calls for complete coordination between the trades working on the structure. As George Grenadier, president of Grenadier points out, "The success or failure of a polysulfide installation depends to a large extent on the preparation of the surfaces to be sealed. The presence of an unusual amount of dirt, greases and mastics can create a cost problem and the curtain wall contractor's men had to be trained to keep the surfaces as clean as possible."

Several years ago, Grenadier attracted considerable attention in building and architectural circles when it was called in to do a remedial sealing job on New York's famous Lever House. The conventional glazing compound installed during the construction of this pioneer venture in glass curtain wall had turned out to be inadequate. Within a short time the material had lost its adhesion, become dry, cracked and pulverized completely.

Remedial Weatherproofing

"As a structural waterproofing contractor," George Grenadier recalls, "our firm was requested by Lever to explore the problems and submit for approval recommended corrective measures." After various compounds had been tested at the site, the experimental panels sealed with a polysulfide compound proved to be an overwhelming success. The material was unaffected by temperature extremes, was resilient and possessed superior characteristics for metal and glass bonding, he notes.

The passing of time, during which the sealants were exposed to severe weather conditions, confirmed Grenadier's initial faith in the caliber and potential of polysulfide sealants. "The weather sealing project at Lever House received considerable publicity," he recalls, "and during the course of the job the building was visited by architects, engineers and contractors from all over the country. As a result, this process of sealing curtain wall structures 'snow balled' and its use has become widespread in the United States and abroad."

On the Union Carbide construction, specifications by the architectural firm of Skidmore, Owings and Merrill call for the use of masking tape above and below each mullion joint to be sealed. The purpose of this procedure is to accomplish a neat, well-tooled joint without the possibility of dirtying the stainless

Pressure application of the polysulfide compound immediately prior to the installation of the steel mullion cap provides effective seal.

After sealing the vulnerable seam, the mullion cap is fitted into place. The member is located at a recessed plateau of the building.

Fitting of the mullion cap forces out excess polysulfide which forms a watertight seal between the metal members of the facade.

steel. Because the polysulfide compound used is aluminum colored, it blends in with the stainless steel members.

"Though the initial cost of polysulfide sealants is higher than conventional glazing and caulking compounds," Mr. Grenadier points out, "it should be emphasized that the latter can be extremely expensive if never-ending maintenance problems and their attendant labor costs are taken into consideration." On the other hand, with proper surface preparation and formulation of the polysulfide sealant, 20 years or more of satisfactory performance can be expected, he believes.

Some Limiting Factors

Properly formulated polysulfide sealants themselves can remain stable for considerably longer periods. The limiting factors in joints are the surface preparation, the amount of movement, unusual temperature and environmental effects that may occur, and the stability of the surface to which the sealant must adhere.

"Polysulfide sealant," Mr. Grenadier explains, "is not a miracle material. To be effective, it must be properly mixed and properly applied to surfaces that have been properly prepared." He goes on to explain that all these "musts" will be to no avail if the material has not been properly compounded. "A list of nationally recognized concerns experienced in the manufacture of these sealants can be obtained from the Thiokol Chemical Corp."

Problems involved in the preparation, application, and even in the limitation of polysulfide sealants have been receiving a good deal of attention by architects, engineers, and contractors in recent months. At a recent building industry meeting held recently in New York City, for example, this question was most frequently asked: "What type of surface preparation is required to get the best adhesion?"

Panel experts recommended that all dust, oil, dirt and water be wiped from the surface to which the sealant is to be applied. A clean rag saturated with xylene or some other suitable solvent could be employed for this purpose. It was further emphasized that while the sealant has been applied successfully to wet metal surfaces, considerable trial testing should be done under these conditions before embarking on any extensive and costly program.

In answer to questions on the effects of heat, light, water and ozone

(1) A conventional caulking gun is used to apply polysulfide sealant to the taped joint of the stainless steel mullions.

(2) Workman uses spatula to obtain a neat and even seal. The masking tape protects the adjoining polished surfaces.

(3) After the polysulfide seal has cured the protective tape is removed.

(4) The aluminum color of the cured polysulfide seal blends in with the stainless steel of the mullions.

on the performance characteristics of a polysulfide sealant, the experts cited various laboratory tests sponsored by Thiokol Corp. These tests showed that properly formulated polysulfide sealants retained a considerable portion of their elastic properties even after six months of continuous exposure at temperatures of 158°F. and 212°F.

The sealants were also shown to be unaffected by water. In controlled tests, adhesion to steel, glass, and aluminum was maintained after continuous exposure for periods exceeding a month.

Sunlight was found to have little or no effect on the sealant's surface; however, it did dull the reflectance. Though in the past ultra-violet light sometimes affected the adhesion to glass, sealants are now being formulated to meet these performance conditions.

Types of Surfaces

In answer to questions about the types of surfaces to which polysulfide sealants will adhere, the panel recommended their use with glass, aluminum, various steels and stainless steel, zinc, lead, bronze, copper, non-oily woods, stone and masonry. Polysulfide materials were not recommended for use where adhesion was required to fluorinated hydrocarbons such as Kel-F, Teflon or Viton.

In many cases, the use of a primer was said to assure better adhesion. This is especially true when porous materials such as stone and masonry are being used. Application of a primer seals the surfaces and keeps water away from the interface.

Mr. Grenadier points out that a lack of knowledge about polysulfide sealants had initially caused a certain amount of resistance to its widespread use. "Executives at Lever's, for example, got an average of a call a day from sombody who wants to 'confirm' the rumor that the sealant job at Lever has failed. They usually answer this by inviting the caller to come down and see for himself just how well it is holding up."

The best expression of confidence in the material, he concludes, is its selection for use on the Union Carbide skyscraper. Some estimate of the size and importance of the job can be gained when it is considered that if the mullions to be sealed were placed end-to-end, they would form a 19-mile stainless steel strip.

Rising from the street to the roof —a distance of 720 feet—the mullions will emphasize the height of the building's tower section. When the building is completed, a special platform lowered down its side will be necessary to carry window washers on the never-ending rounds required to keep the "skin's" 325,000 square feet of glass clean.

In addition to the 52-story tower structure fronting on Park Avenue, the Union Carbide Building will have a 12-story section fronting on Madison Avenue. All and all, the structure will contain approximately 1,500,000 square feet of space, making it one of New York's largest office buildings.

The building is expected to accommodate about 5000 people. Plans call for its completion and occupation by Union Carbide some time early 1960.

The Outlook for Synthetic Adhesives

By JAMES M. MARGOLIS
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The use of adhesives has shown a remarkable growth curve over the past decade or two which has probably not received the same attention as have products such as aluminum, synthetic detergents, and plastics. Moreover, there is no sign either from statistics or general views that this growth will level off in the foreseeable future. On the contrary, the rise in adhesive sales will probably continue for a good many years.

Where are the growth centers in this broad industry? It is commonly known that the synthetics are the pacemakers. The combined tonnages of phenolic, urea and melamine, and vinyl for adhesives have grown at an annual rate of 15 to 20 per cent since 1952, according to U.S. Tariff Commission figures. Animal glues, which represent about half of the protein-base adhesives, have remained very constant over this same period.

These synthetics plus the animal glues probably represent more than 40 per cent of all adhesives. A major portion of the remaining 60 per cent is represented by vegetable and rubber based adhesives which have made gains at a slower rate than the synthetics.

Figures 1 and 2 show graphically the rapid growth of these synthetics compared to other well-known fast moving products. Figure 1 compares them to synthetic detergents and plasticizers. The line, representing phenol, urea and melamine, and vinyl adhesive sales, shows a rate of growth comparable to synthetic detergents sales. Figures for plasticizers are for production and are presently running over 450 million pounds. In estimating values for synthetic adhesives on this graph, their use in laminates has been omitted. Also, the figures are estimated on a resin basis content which excludes any compounding agents such as plasticizers, stabilizers, fillers that might be added.

Figure 2 compares production of primary aluminum as well as the plastics and resin field to synthetic adhesive sales. From about 1940 to date, aluminum and synthetic adhesives have grown at a fairly comparable rate of per cent per year. Aluminum figures are ten-fold greater than those for adhesives. The plastics industry has been growing at a somewhat faster rate.

Focus on Phenolics

Figure 3 shows in greater detail synthetic adhesives sales from 1952 through 1958. There has been a tendency to plateau over the past three years preceded by a very substantial increase in 1955. The increase at that time was attributed to practically all major uses of the synthetic adhesives. But particular attention might be focused on the use of phenolics for thermal insulation.

Phenolics are used here as a bonding agent with rock wool and glass fiber. In 1955 sales of phenolics for thermal insulation jumped 40 per cent to over 50 million pounds, and has remained at this level to 1959. It has surpassed the sales of phenolics to laminators as well as to plywood users, but not by very much. Thermal insulation, then, appears to be a top consumer of phenolic bonding agents as it has been over the past few years. It should contribute to a significant increase this year.

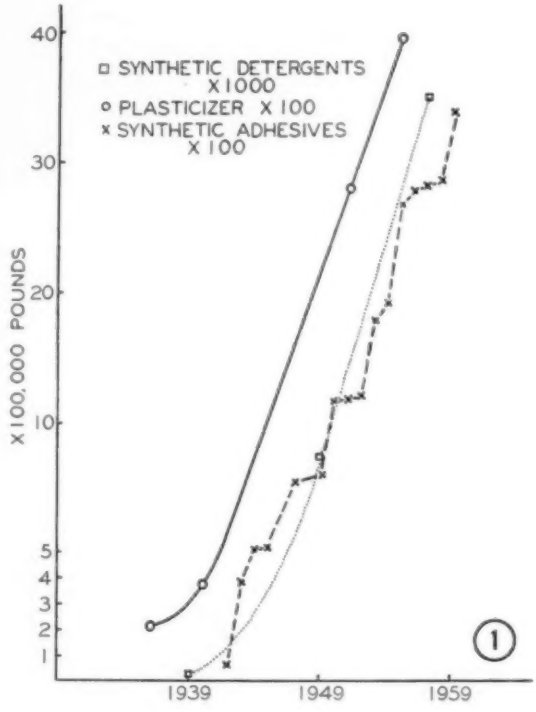
On a resin content basis, excluding laminating use, 1958 sales were estimated at 290 million pounds. Compared to other sales and production figures which have been developed, this is a conservative estimate. The reason for this is probably because ten per cent was deducted from dry basis figures which include compounding ingredients. Ten per cent has been said to be on the high side for an average.

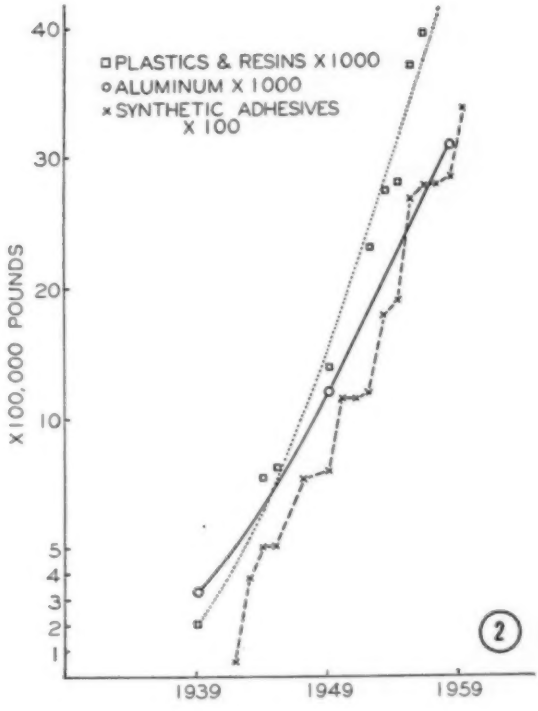
The data in Figure 3, however, can be correlated to Tariff Commission statistics. Figure 4 demonstrates this correlation more clearly. On the basis of 290 million pounds for 1958, a partly considered, partly arbitrary estimate of 340 million pounds is proposed for 1959—or a 20 per cent increase over last year.

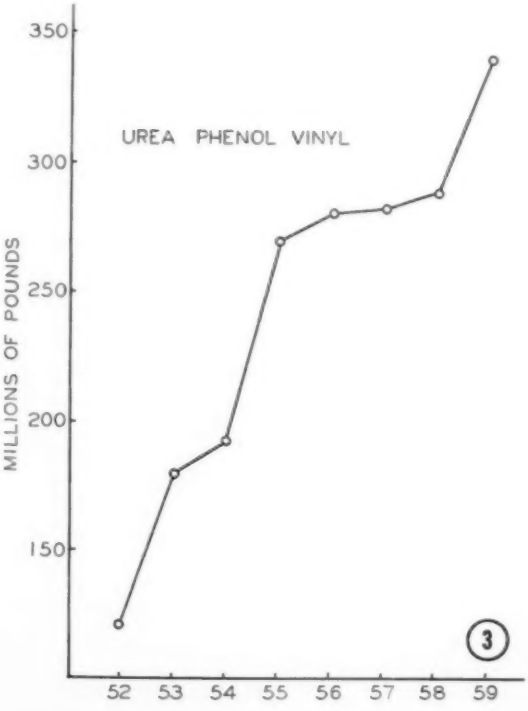
Figure 4 is a further detailed sales chart of these main adhesive groups. This time figures are from U.S. Tariff tables directly, and, therefore, include sales to laminators, and are on a dry basis. Since 1952, phenolics have gained rapidly over urea and melamine combined. Based on an estimated 200 million pounds for last year, increased use of phenolics in particle board, plywood and laminates could result in an increase of as much as 50 million pounds. The drop shown in 1958 was due to a decline in most major uses with the exception of plywood which held its own last year.

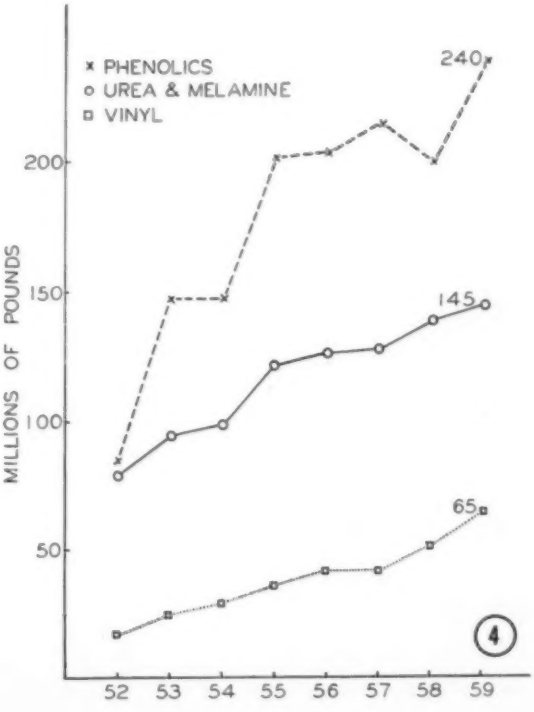
The urea and melamine curve also includes sales to laminators which amounted to approximately 24 million pounds per year over the past

Growth Patterns of Synthetic Adhesives









two years. Practically all of the rest went to the plywood industry. If the plywood industry continues to grow, then the urea adhesives ought to show a continued increase, as they have been through the 1950's.

The past five year trend for vinyl adhesives suggests an extrapolated sales volume in the order of 65 million pounds.

Totalling up these three proposed estimates: 240 plus 145 plus 65, we arrive at 450 million pounds sales for 1959, on a dry basis, and including laminates. Recalling Figure 3, the projected total on a resin basis, excluding laminating, was 340 million pounds. Combined urea and phenol for laminating has been about 70 million pounds for the past two years. Adding these two figures, we get 410 million pounds. Ten per cent of the dry basis content was deducted previously to convert to resin basis.

Figures in Agreement

Therefore, if ten per cent of 410 million, or 40 million, is added to our 410, a total of 450 million pounds is obtained. This coincides with the 450 million pounds predicted for 1959 sales, on Tariff Commission reports. The same calculation can be applied to 1957 and 1958: namely, adding 70 million pounds for laminating and ten per cent to this sum. The results are in very close agreement with Tariff Commission figures for these two years; and they should be, since the 70 million pounds and ten per cent are constant over this period.

Turning now to a qualitative view, what are some of the fields of activity that might be worth watching this year? By looking back we can safely predict a long-term climb. But, last year did not turn out to be a pacemaker. Why might this year be one? The answer, I believe, lies partly in the field of building construction materials.

In the past several years four fields have steadily been using more synthetic adhesives: building materials, do-it-yourself materials, aviation and automotive. It may be now that consumption of synthetic adhesives in the do-it-yourself uses has reached a high which is plateauing and cannot be viewed as a good outlet for additional resin capacity in the future. The aviation and automotive fields, on the other hand, are still relatively small volume users of these adhesives, compared to their potential. Eventually, they ought to provide a large market, particularly for the epoxies.

Of the four fields, building materials seem to hold the best promise for the immediate future. One area, for example, which seems to be growing at the fabricating level is honeycomb sandwich panels, in which foamed aluminum or plastics are bonded between steel or plastics sheets. These panels have a market in aircraft and for curtain walls in home and office buildings which has not been fully tapped.

In meeting the demands of building materials, adhesives with high temperature stability and weatherability are required. Some of the epoxies being introduced are meeting these requirements. For example, by combining novolac instead of conventional bisphenol A with epichlorohydrin, a high temperature epoxy results which is said to have use in metal fabricating. It can also be used in electrical printed circuits as well as in structural shapes made out of glass fiber reinforced plastics.

Epoxy resin is being offered to bind concrete, competing with polyvinyl acetate, rubber latex and butadiene styrene. Single component epoxy adhesives for application up to 200 degrees centigrade are also being marketed to bond metal, glass, ceramics and cement.

Epoxies are largely used for bonding metal-to-metal or metal-to-plastics. They should have a good dollar volume outlet in the fix-it-yourself area where the individual consumer is not buying in volume and is not likely to be as cost-conscious as the industrial purchaser. This is a good volume outlet, providing the fix-it-himself consumer doesn't mind mixing two components, the hardening agent, an amine usually, to the epoxy resin. There have been efforts to overcome this, and one product being offered holds the hardener within an inner tube inside the epoxy container. The two parts automatically mix as used.

In surveying the end-uses that may account for an increase in synthetic adhesive sales, we should distinguish between the bread and butter applications—packaging, paper, furniture —and the exotic uses such as missile construction.

According to the Adhesive Manufacturers Association, 53 million pounds of synthetic adhesives went into packaging and paper in 1950 and by the end of 1958 this tonnage had increased almost three-fold to 153 million pounds. By way of comparison, vegetable glues during this same period for the same uses climbed from 226 to 250 million pounds, and animal glues actually slipped off from 28 to 22 million pounds. The increased use of plastics in packaging will no doubt propel the sales of synthetic adhesives to another new high in 1959.

Plywood, another bread and butter user, particularly of urea adhesives, has been growing strongly since the early 1940's. In fact, the sudden jump in synthetic adhesives between 1942 and 1943 has been ascribed specifically to plywood use in the 1943 Tariff Commission report. Since that time, phenol and urea for plywood has reached a level of more than 150 million pounds. Plywood, like packaging and paper, ought to contribute to this year's predicted increase of 20 per cent over last year for phenol, urea, and vinyls combined.

Laboratory Approach

The non-synthetics, or natural glues, are competing for a greater share of the market, also. The same as synthetics, they are approching the problem through the laboratory. The development of enzymes, for example, has greatly improved the production of starch glues as well as the end-product.

The spearhead of synthetic adhesives progress is in technological development. New polymers, new formulations and applications at commercially feasible cost are coming from research. Monomers are being synthesized to create resins with predictable properties. Test procedures are being developed and standardized—largely through the efforts of the ASTM—to control applications and performance of new adhesives as they are introduced.

It might be interesting to spotlight the status of statistics on adhesives. Long-term and at the same time detailed data is often not readily avail-

About the Author . . .

J. M. MARGOLIS graduated from M.I.T. in 1952 and worked at Dewey and Almy Chemical Co. as a research chemist in rubber formulation and colloidal chemistry. In 1958, he started Chemical Marketing & Research Co., which specializes in market development in the polymer field.

able. Sometimes, too, the data which is available is not in complete agreement. However, close examination of different sets of values that appear to conflict frequently reveals where the difference exists.

For example, the end-uses included may vary—laminating may be added or omitted. One group of figures may be on a dry basis, another on resin content basis. The more these conditions are specified, the easier it is to correlate sources. Nevertheless, even with differences, the trends are not necessarily affected to any significant degree.

In some cases, the order of magnitude is not even altered appreciably. The reason for this is that the variants may be either relatively constant, or their volume does not affect the over-all picture.

For example, phenolics going into laminating (not including plywood) has fluctuated around 46 million pounds plus or minus 4½ million pounds for the past seven years—from 1952 through 1958. Whether or not phenolics going into laminates is included in total sales figures will certainly affect the gross figures, but it does not alter the trend during this period as much. Epoxy adhesive sales are perhaps around 2½ million pounds. While their percentage increase has been steep, nevertheless, the figure is low enough not to affect total synthetic adhesives sales values.

Note: The author wishes to acknowledge the cooperation received from individuals at the Adhesives Manufacturers Association of America, Stanford Research Institute, Borden Chemical Co., Reichhold Chemicals, Inc., Soap and Glycerin Producers Association of America, and the Aluminum Association. They are not, of course, responsible for any of the opinions presented.

Adhesive-Bonded Sails

California sail maker produces a better canvas faster and cheaper by switching from stitching

A San Diego sail making firm has begun adhesive bonding, rather than sewing, critical areas of large sails as a means of improving their speed, performance and versatility. Lowell North, one-time Star Class world sailing champion and owner of the North Sail Company, reports that the new technique has also brought about reductions in production time and expense.

In competitive sailing, many elements contribute to the speed of the boat, but one of the most important considerations is the precision with which the fullness, or curve, of the sail can be controlled. In light winds a full or deeply curved sail is essential for top performance, while a flat or slightly curved sail is required in heavy winds.

Here is how this unique sail with built-in "draft control" is fabricated. In place of the conventional bolt rope that extends vertically along the luff of the mainsail, North substitutes an elastic tape consisting of ⅜-inch neoprene tubing adhesive bonded within a long nylon covering sheath. The forward edge of the mainsail is then fitted into the overlapped nylon sheath and machine sewn.

Since sails are made up of strips of sailcloth sewn on the bias, the tautness of the elastic tape influences the curvature of the entire sail. When the rope is pulled downward, the cloth is stretched and the sail becomes flat or only slightly curved. When the tape is slackened, tension on the cloth is relaxed and the sail becomes full again.

According to North, this control feature not only enables one sail to do the work of two, but in addition increases the range of wind velocity under which a sail can operate efficiently. Adhesive bonding, he adds, proved the only practical method by which neoprene tubing, the nylon covering unit and the sail edge can be made to stretch as a unit.

North also developed a novel method for bonding rather than sewing aluminum headboards to the peak of a sail. His technique is to bond a flat aluminum headboard plate between two sheets of Dacron about three times the size of the headboard. In this sub-assembly operation, he uses Metlbond 3135, a structural adhesive that normally cures at room temperature and slight pressure, but may be speeded by heating to 250°F. Then the Dacron portion of the bonded unit is machine-sewn to the sailcloth.

A bonded headboard, North points out, offers both production and performance advantages. Production-wise, about one man-hour per sail is saved over hand-sewing.

Note: Metlbond 3135 is a product of Narmco Resins & Coatings Co., Costa Mesa, Calif.

Proof of "draft control" in bonded sails is shown when elastic edge tape is drawn taut, stretching cloth throughout the sail.

Aluminum headboard plate is bonded between two sheets of Dacron. The sub-assembly is then machine-sewn to sailcloth.

Sealing Trailer Truck Roof Leaks

After the area around the seam is cleaned, a coat of neoprene primer and a coat of neoprene cement is laid down.

In spite of the precautions taken by most manufacturers of closed metal top trailers, roof joints tend to open up after years of all-weather use. An adhesive sparked technique, however, has recently been developed to repair leaking seams permanently and provide a weatherproof seal for the life of the trailer.

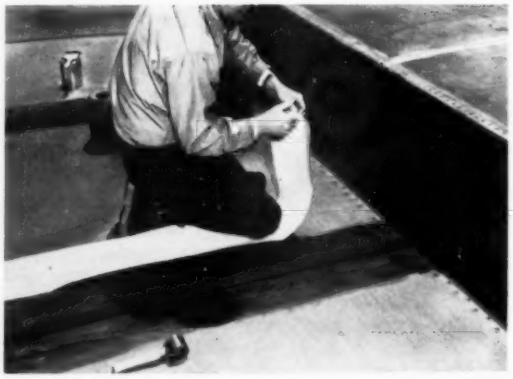
The new technique eliminates repair difficulties caused by conventional methods relying on liquid or putty-type caulking compounds. According to reports from truckers, the latter provided only temporary protection as the compounds would dry out and crumble after their oil bases had evaporated.

Repair materials for the new technique—urethane foam, neoprene-coated nylon tape and a neoprene adhesive—are available in a special kit marketed under the name of Nylo-Flex. Application is simple and inexpensive. Timed tests have shown that two maintenance men previously unfamiliar with the technique can seal up to ten seams an hour on a clean roof.

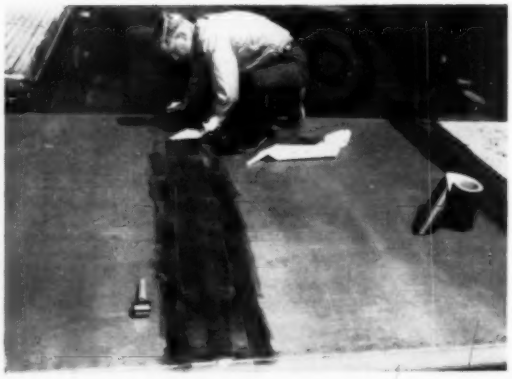
Briefly, the repairs are made as follows. First, the area around the seam is cleaned and a coat of primer is applied. A coat of the cement is then laid down and a strip of urethane foam placed over the seam. Next, the backing is peeled off the neoprene-coated tape which is then adhered over the urethane cushioning strip. A roller is used to bond the tape firmly.

The finished seam allows both the foam and tape to "see-saw" with the road motions of the plates in the trailer roof. Periodic examinations of test trailers repaired in this manner have shown no change in either adhesion or appearance after long periods of operation.

In the next step, the entire length of the seam is carefully covered with a strip of resilient urethane foam.



The backing is stripped from the neoprene-coated nylon tape which is cemented in place over the urethane cushioning.



The repaired seam is waterproof and cushioned against ripping. A roller is used to make sure the tape is firmly bonded.

Note: Nylo-Flex is a product of Haartz-Mason, Inc., Watertown, Mass.

Adhesive Deterioration in Metal Bonds at High Temperatures—Part 2

By J. M. BLACK and R. F. BLOMQUIST

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3—Further studies of aluminum bond deterioration

The first part of this article covered studies of adhesives by infrared spectro-photometry, and the deterioration of metal bonds in nitrogen and air.

The preliminary study of the thermal deterioration of FPL-891 adhesive by infrared absorption of unsupported films and in aluminum and stainless steel bonds revealed that the resistance of the adhesive to thermal degradation in an aluminum bond prepared under optimum conditions was quite high and apparently was not closely related to the rapid oxidation observed in an unsupported film in air at elevated temperatures. However, in previous work on the development of heat-resistant adhesives(1) it was shown that not all aluminum bonds made with phenol-epoxy resin adhesives were resistant to thermal degradation. The preparation of the metal surface for bonding and the bonding conditions used were important variables and had to be controlled within certain limitations. A more complete explanation of the causes and effects of these variables was needed to understand fully their influence on the resistance of an adhesive bond to thermal degradation.

This phase on the study was conducted on FPL-878 adhesive, a phenol-epoxy resin formulation. (Appendix) in 0.5 inch lap shear joints of 0.064 inch thick 24T-3 clad aluminum alloy. This adhesive was known to have somewhat higher resistance to thermal deterioration than the simpler FPL-891, used in the previous study, when employed under optimum bonding conditions.

Various chemical and electrolytic methods were used in preparing the surface of the clad aluminum alloy for bonding. Surfaces with distinctly different physical appearances or surfaces assumed to be chemically different were obtained. The results of tests of bonds to these surfaces gave further insight into the problems of both the adhesion characteristics of the metal surface and the effect of the metal surface on the resistance of the adhesive to thermal degradation. The results of lap shear tests at room temperature of heat-aged and unaged specimens bonded with FPL-878 adhesive at 320° F. for 60 minutes after a precure of 30 minutes at 200° F. are shown in Table II.

The aluminum bonds prepared by the first four methods shown in Table II—A-1, A-2, A-3, and A-4—all appeared to have similar strength properties initially and also after aging at 550° F. for 48 hours. These methods of preparing the aluminum for bonding etched the surface noticeably and therefore could be considered as effective in increasing the surface area. Presumably they were also effective in removing the aluminum oxide layer from the original surface and in leaving a rather pure metallic aluminum surface for bonding, at least momentarily.

Subsequent drying of the treated surfaces at room temperature and short storage (less than 24 hours) before bonding would probably allow a new oxide layer to form, but this would be expected to be a comparatively shallow oxide layer compared to the oxide layers intentionally formed by other oxidizing chemical and electrolytic methods. In some cases, the metal surfaces were heated at 550° F. after the chemical etching to dry the treated surfaces thoroughly and to help remove absorbed gases, acids, or alkalies from the surface that might adversely affect the bonding or aging characteristics of the adhesive.

The possible effects of such heat treatment on the physical properties of the metal are not known. The data showed that heating the metal for one hour at 550° F. before bonding was of no particular advantage in the methods A-1, A-2, A-3, and A-4, indicating that any adsorbed chemicals from the treating solution had probably been adequately removed by the standard rinse in tap water and distilled water.

The aluminum prepared by immersion in a solution of sulfuric acid and sodium dichromate (Method A-5 or Method A in Appendix) de-

Note: Figures 1-4, Table I and the Appendix appeared in Part 1, May, 1959.

veloped bonds of somewhat higher initial strength and significantly greater resistance to thermal degradation than those obtained by methods A-1, A-2, A-3, and A-4.

The results of tests employing method A-5 compared with method A-3 show the value of using sodium dichromate in sulfuric acid solutions to improve the bonding surfaces. The improved bonding surfaces presumably come about as a result of the strong oxidizing power of sodium dichromate in the presence of sulfuric acid to form an aluminum oxide layer, under controlled conditions, that has improved adhesion and cohesion characteristics.

Because the oxide layers formed by such controlled chemical means are known to be highly adsorptive, the adsorption of acid from the chemical treatment as a result of inadequate washing of the surface is likely to be a problem. The effect of adsorbed acid is shown by the results of tests on metal prepared by Method A-5b where the metal was rinsed in one per cent sulfuric acid solution and then air dried following the regular immersion in the sulfuric acid-sodium dichromate solution. These bonds were signficantly low in initial strength and in resistance to thermal degradation. In Method A-5c, a modification of the sulfuric acid-sodium dichromate method, the metal surfaces were placed in boiling water for one hour before bonding.

Provides Sealing Action

This treatment of the aluminum is considered by aluminum manufacturers to have a sealing action on the porous aluminum oxide by converting it to the monohydrate, which effectively closes the pores and destroys the adsorptive and high adhesion characteristics of the surface. The result of tests on joints prepared by Method A-5c tend to confirm this, as shown by the low initial strengths of joints as compared to those prepared by Method A-5. The introduction of water into the oxide layer to form the monohydrate also reduced the resistance of the adhesive to thermal deterioration.

An electrolytic chromic acid anodize treatment, which also forms an oxide layer on the aluminum surface, was used in Methods A-6, A-6a, and A-6b followed by rinsing in water (A-6), heat treating at 400° for one hour (A-6a), and by sealing in boiling water (A-6b). Results of tests of specimens prepared by these methods show that the anodizing method was particularly effective in promoting good adhesion, except when water sealing was used. Resistance to thermal degradation was high when the metal was heat treated for one hour at 400° F., but very low when water sealed to form the hydrated oxide film.

A reducing type treatment employing sulfuric acid and oxalic acid (Method A-7) which would be expected to remove the corrosion-resistant aluminum oxide layer resulted in bonds that had good initial strength but were low in resisting thermal degradation.

The results of the work on surface

Table II—Effects of Metal Surface Treatments for Clad Aluminum Alloy on Heat Aging Properties of Joints Made with FPL-878 Adhesive

Method	*Composition of Treating Solution*	*Conditions of Immersion*[1]	*Heat Treatment*[2]	*Shear Strength at 80° F.*		
				Initial	*After 48 hours at 550° F.*[3]	
				P. s. i.	*P. s. i.*	*Percent*
A-1	6 N-NaOH	80° F. for 1-5 minutes		1,522	916	45
A-1	6 N-NaOH	80° F. for 1-5 minutes	1 hour at 550° F.	1,548	1,014	32
A-2	1N-HCl	140° F. for 5 minutes		1,562	1,054	18
A-2	1N-HCl	140° F. for 5 minutes	1 hour at 550° F.	1,656	894	24
A-3	H_2SO_4 (10 percent by weight)	150° F. for 10 minutes		1,524	1,042	35
A-3	H_2SO_4 (10 percent by weight)	150° F. for 10 minutes	1 hour at 550° F.	1,580	1,016	20
A-4	H_2SO_4—20 cc HF—30 cc H_2O—50 cc	80° F. for 5 minutes		1,470	958	20
A-4	H_2SO_4—20 cc HF—30 cc H_2O—50 cc	80° F. for 5 minutes	1 hour at 550° F.	1,590	930	15
A-5	H_2SO_4—10 grams, $Na_2Cr_2O_7$—1 gram, H_2O—30 grams	150° F. for 10 minutes		2,152	1,306	15
A-5	H_2SO_4—10 grams, $Na_2Cr_2O_7$—1 gram, H_2O—30 grams	150° F. for 10 minutes		2,152	[4]894	5
A-5a	H_2SO_4—10 grams, $Na_2Cr_2O_7$—1 gram, H_2O—30 grams	150° F. for 10 minutes	1 hour at 550° F.	2,216	[4]932	5
A-5b	H_2SO_4—10 grams, $Na_2Cr_2O_7$—1 gram, H_2O—30 grams	150° F. for 10 minutes	(Rinsed in 1 percent H_2SO_4 and air dried)	170	126	98
A-5c	H_2SO_4—10 grams, $Na_2Cr_2O_7$—1 gram, H_2O—30 grams	150° F. for 10 minutes	(1 hour in boiling H_2O and air dried)	892	[4]240	89
A-6	Chromic acid[5] anodize	95° F. for 45 minutes	1 hour at 400° F.	2,370	[4]522	68
A-6a	Chromic acid[5] anodize	95° F. for 45 minutes	(1 hour at 400° F.	2,296	[4]1,002	20
A-6b	Chromic acid[5] anodize	95° F. for 45 minutes	(1 hour in boiling H_2O and air dried)	1,026	[4]310	64
A-7	H_2SO_4—10 grams, oxalic acid—10 grams, H_2O—80 grams	190° F. for 10 minutes		1,534	[4]386	87

Notes: [1]After immersion in the chemical bath, the metal surfaces were rinsed in cold tap water, distilled water, and then air dried. [2]The metal was heated at the elevated temperatures and cooled again to room temperature before application of the adhesive. [3]The percentage value is the estimated percentage of bond area showing discoloration. Each value is the average of at least 5 specimens. [4]Specimens aged at 550° F. for 200 hours and tested at 80° F. [5]Method BA-1 in Forest Products Laboratory Report 1842.

treatment of aluminum before bonding showed that an aluminum oxide surface is one of the most desirable surfaces for bonding to promote high initial strength and resistance to thermal degradation. Small amounts of residual acid or even absorbed water will seriously reduce the initial adhesion and the thermal resistance of the bond.

In addition to the preparation of the metal surfaces for bonding, one would also expect the conditions for assembly and bonding in the process of making a metal bond to be highly important variables in the performance of an adhesive at elevated temperatures. Based on earlier work(1) and also on further work in the present study it seemed that the precuring process was probably one of the most critical phases in the bonding procedure as it affected the thermoplastic properties of the adhesive at elevated temperatures and the resistance of the bond to heat aging.

A precure is generally employed with solvent-type adhesives to remove solvents to prevent the formation of bubbles of volatile materials and voids in the bond during the subsequent cure of the resin in the pressing operation. In addition to poor initial bonds due to blistering in hot pressing, the presence of these entrapped solvents and other volatiles in the joint has also been considered as having an adverse effect on the adhesive film during heat aging.

Effective Solvent Removal

Since the solvents usually employed in adhesives are quite volatile, the most effective and practical way to remove them from the adhesive film would appear to be to dry or precure at as high a temperature, and for as long a period, as possible without adversely affecting the resin components by overcure and reduced flow properties.

A study of the effects of precure on the resistance of a phenol-epoxy adhesive, FPL-878, showed that the complete removal of solvents by adequate precure is probably not the most important change that occurs during the precuring period. Table III shows test data for aluminum bonds, of the lap-shear type bonded with this adhesive and illustrates how the precure temperature and the length of time of precure influenced both the resistance of the bond to thermal degradation, as shown by the strength of joints after aging 16 hours at 550° F., and the resistance of the bond to thermal softening, as shown by the strength of joints tested immediately at 500° F. The metal was prepared by Method A (Appendix) and bonded for 60 minutes at 320° F. under 50 pounds per square inch pressure. Each psi value is the average of five test specimens.

The results of these tests showed that as the period of time at a given precure temperature was increased, the resistance of the adhesive to thermal degradation (as shown by the strength at 80° F. after 16 hours at 550° F.) was decreased. The reduced strength after heat aging was accompanied by very marked evidence of thermal deterioration of the adhesive as indicated by the presence of discolored areas in the bond. The strength of bonds tested immediately at 500° F. without aging was also decreased as the precure time was increased. The latter effect could be interpreted as indicating a reduction or modification in the degree of crosslinkage with a resultant increase in thermoplasticity of the adhesive.

The adverse effects of the longer precure periods were not considered as resulting from advanced cure of the resin with subsequent poor flow and inadequate fusing of the faying surfaces during the pressure and curing cycle since all bonds had very similar satisfactory strengths initially at room temperature, and the appearance of the bonds in initial tests indicated adequate flow of the adhesive during bonding. Neither is it likely that more complete removal of solvent from the adhesive by the longer precure periods could have an adverse effect since the solvent presumably has no known role in the crosslinkage and curing reactions of the resins.

Study of the bond areas after test revealed that there was a reduced amount of branching of fewer tunnel-like passages (Figure 4-B) for escape of volatiles in the specimens that were precured for the longer periods, particularly when precured at 250° and 275° F. It was also observed that joints with lower strengths after aging always had dark brown or black spots of deteriorated adhesive in the bond as shown in Figure 4, C and D.

These spots occurred in bonds with longer precure, particularly at 275° F. and were located both within the bonded area as well as at the edges of the bond. The spots were round and oval shaped and appeared to have been formed by progressive deterioration starting from a single nucleus, as the center of the spots were frequently darker in color than the surrounding area. The spotted areas of discoloration were never noted when bonds, precured at 200° F., were heat aged.

Table III—Aluminum Bond Resistance to Thermal Degradation and Softening

Precure Conditions Time	*Temp.*	*Shear Strength— At 80° F. after 16 hours at 550° F.*	*Immediately at 550° F.*
Min.	*° F.*	*P. s. i.*	*P. s. i.*
30	200	1,286	1,246
60	200	1,066	.....
20	250	1,174	1,020
40	250	598	660
60	250	576	210
10	275	1,082	1,060
15	275	984	600
25	275	366	264

Since adverse precure conditions resulted in both a loss in resistance to thermal degradation and a loss in the immediate strength of joints at elevated temperature, one logical explanation for this behavior appeared to be that some crosslinking agent or thermal stabilizer was lost by volatilization during the more severe precure conditions.

Crosslinking Agent

One adhesive component, considered most likely to be influenced by heat, is formaldehyde, which is an important crosslinking agent for phenol resins. If unreacted formaldehyde were lost excessively during the precure, it could result in a lower degree of crosslinkage and a loss in strength at elevated temperatures. To investigate this possibility, additional formaldehyde was added to FPL-878 adhesive by adding hexamethylenetetramine and allowing it to react with the adhesive by refluxing before application.

In this work it was assumed that the longer refluxing of the adhesive components would advance the cure of the resins slightly and might also partially react the formaldehyde and the resins to make the formaldehyde more stable and less likely to be driven off by subsequent heating during precure. This hypothesis was not substantiated by the results of tests (Table IV) made on conventional lap joints of aluminum with this modified formulation of FPL-

Table IV—Tests on Lap Joints of Aluminum with Modified Formulation of FPL-878

Precure Conditions		Amount of Hexa	Reflux Time	Shear Strength
Time Min.	Temp °F.	Percent	Min.	P. s. i.
30	200	0	15	1,388
30	200	0	120	1,754
30	200	5	15	1,276
30	200	5	120	912
15	275	0	15	824
15	275	0	120	542
15	275	5	15	448
15	275	5	120	664

878 adhesive containing five per cent hexa.

In the table, the per cent by weight of hexamethylenetetramine is based on resin solids of FPL-878; reflux time refers to the time all adhesive components of FPL-878 were refluxed together at steam bath temperature. Tests of shear strength were made at room temperature after 16 hours at 550° F. Each psi value expressed is the average of five specimens.

The addition of hexa did not significantly improve the thermal resistance of bonds precured at either 200° or 275° F. and in some cases appeared to have an adverse effect. The length of time of refluxing had no consistent, marked effect in either increasing or decreasing the resistance of bonds to aging at elevated temperatures. These data indicate that the loss of formaldehyde during the more severe precure conditions was probably not the real cause of reduced immediate strength at elevated temperatures or the lowered resistance to thermal degradation. In this experiment the precure conditions were again the most significant bonding variables that influenced the thermal resistance of FPL-878.

Another possible explanation for the adverse effects of the higher precure temperature and longer precure period may be the formation of undesirable organic peroxides or other intermediates as by oxidation of residual solvents and other adhesive components in the adhesive film during the open exposure to heat and air drying during the precure period. These reaction products could be expected to retard the cure of the resins and act as centers of subsequent deterioration during heat aging. To check this hypothesis, bonds of aluminum were made with FPL-878 adhesive by precuring the adhesive for 15 minutes at 275° F. in atmospheres of oxygen, air, and nitrogen. If the formation of peroxides or similar intermediates were the cause of subsequent deterioration, precuring in oxygen would likely cause such compounds to form more readily and precuring in nitrogen would retard their formation.

The results of these experiments showed there was no real improvement in the joint strength of bonds at room temperature (80° F.) after aging 16 hours at 550° F. when precured in nitrogen over those precured in air or in oxygen. The shear strength of bonds cured in air was 312 psi; the shear strength of bonds cured in oxygen was 548 psi; the shear strength of bonds cured in nitrogen was 468 psi. Each value is the average of five test specimens.

Complex Reaction

The actual chemical reactions in curing a combination of two different resins, each of varying polymer sizes, is understandably complex. It is quite likely that changes in the precuring as well as curing temperatures could cause variations in the rates of the curing reactions of these resins with themselves and with each other. Such precuring temperature effects on these reactions could be another possible explanation for the observed dependence of heat resistance of the bonds on the precuring conditions. The higher precure temperatures presumably could cause the epoxy resin to react first with the uncured and relatively small phenol resin molecules and thus retard the further condensation and cure of the phenol resin with itself to form a highly infusible and insoluble polymer.

However, a study of the effect of adhesive composition revealed (Table V) that adhesives composed of phenol resins alone (Formulas A and B) showed definite signs of deterioration at 550° F. after a precure at 275° F. for 15 minutes as did the adhesive compositions of phenol and epoxy resins (Formulas C to I) under similar conditions as shown by the presence of discolored spots in the adhesive bond. At a precure temperature of 200° F. for 30 minutes there was no evidence of the spots characteristic of thermal deterioration in the aluminum bonds for any of the adhesive formulations.

In Table 5, the solvent indicated was used to dissolve the resin components and to thin the adhesive for application by brush. E.Ac. is ethyl acetate; MEK is methyl ethyl ketone. Shear strength values given are the average of five specimens.

The value given in parenthesis along side the psi value is the percentage of bond area showing discoloration or thermal deterioration. The percentage of bond area showing deterioration in bonds precured at 200°F. for 30 minutes was ten to 20 per cent—which was the area occupied by the branches of tunnel-like voids with no spot-type detrioration present.

Epoxy resin, Epon 1007, used alone in formula J as an adhesive and applied as a solution in ethyl acetate showed no visible spots of thermal deterioration at either precure condition. The addition of varying amounts of epoxy resins (Formulas C to G) to the phenol resin in different adhesive formulations showed no particular trend in

Table V—The Effect of Adhesive Composition and Precure on the Joint Strength of Aluminum Bonds After Aging at 550° F.

Formula	Adhesive Composition				Solvent	Shear Strength at 80° F. After 16 Hours at 550° F. When:	
	Durez 16227	Bakelite BV9700	Epon 1007	Epon 1001		Precured 30 minutes at 200° F. P.s.i.	Precured 15 minutes at 275° F. P.s.i.
	Parts by weight of solids						
A	10				E.Ac.	1,406	812 (36)
B	10	2			E.Ac.	1,434	986 (53)
C	10	2	0.5		E.Ac.	1,346	1,020 (42)
D	10	2	1.0		E.Ac.	1,180	922 (35)
E	10	2	2.0		E.Ac.	1,132	584 (78)
F	10	2	4.0		E.Ac.	996	822 (31)
G	10	2	2.0		MEK	850	512 (63)
H	10	2		0.5	E.Ac.	774	446 (67)
I	10	2		1.0	E.Ac.	710	508 (66)
J			10.0		E.Ac.	540	476 (0)

Table VI—The Effect of Phenol Resin Composition and Precure on the Joint Strength of Aluminum Bonds After Aging at 550° F. and Immediately at 500° F.

	Composition[1]	Precure		Shear Strength[2]		
		Minutes	°F.	Initially at 80° F. P.s.i.	At 80° F. after 16 hours at 550° F.[3] P.s.i.	Immediately at 500° F. P.s.i.
1	None	30	200	1,704	1,410 (13)	672
		15	275	1,764	1,020 (38)	590
2	0.7% Benzene Sulfonic acid (BSA)	30	200	1,554	1,446 (14)	920
		15	275	1,516	986 (32)	776
3	0.7% B.S.A. and 5.0% hexa	30	200	1,896	1,154 (22)	554
		15	275	2,040	978 (44)	406
4	1.0% phenol	30	200	1,606	1,308 (18)	650
		15	275	1,694	1,324 (18)	744
5	1.5% pyridine	30	200	1,726	1,606 (19)	846
		15	275	1,840	1,630 (22)	976
6	1.5% diethylethanolamine	30	200	1,876	1,564 (19)	926
		15	275	1,720	1,470 (20)	828
7	1.5% triethanolamine	30	200	1,156	840 (21)	436
		15	275	1,286	994 (20)	486
8	1.5% aminopropyl morpholine	30	200	1,566	1,510 (14)	864
		15	275	1,586	1,442 (37)	1,140

Notes: [1]Phenol resin, Durez 16227, was used as the bonding agent. The percentages of other materials added were based on the weight of the phenol resin solids. Hexa is hexamethylenetetramine. [2]Each value is the average of 5 specimens. [3]The values in parentheses are percentages of bond area showing discoloration or thermal deterioration.

the effect of the ratio of phenol resin to epoxy resin in the thermal resistance of bonds precured at 275° F.

The use of a lower molecular weight epoxy resin (Epon 1001), with approximately the same number of reactive epoxy groups on the resin molecule as the Epon 1007 resin and considered to be more reactive with the phenol resin because of the lower molecular weight, did not materially increase or decrease the amount of thermal deterioration observed in the broken bonds (Formulas H and I) although joint strengths after heat aging were much lower when Epon 1001 was used. The use of methyl ethyl ketone solvent in formula G gave results similar to those obtained with ethyl acetate solvent (Formula E).

The work on adhesive compositions indicated that the resistance of an adhesive composed of phenol and epoxy resins to thermal deterioration was not only dependent upon the precure conditions but also suggested that the phenol resin in the composition might be the source of initial deterioration; spots of deteriorated resin occurred in the bonds when phenol resin was used alone as the bonding agent and no degradation was observed on straight epoxy resin bonds.

Subsequent studies were directed toward learning what possible effect the precure temperature could have on the thermal resistance of a phenol resin, Durez 16227, with various catalyst systems, but without any epoxy resin, when employed as the bonding agent for aluminum. The data in Table VI showed that the resistance to thermal aging of FPL-878 adhesive after precuring for 15 minutes at 275° F. could be improved by addition of certain agents which could be considered as catalysts. In tests at room temperature, after aging 16 hours at 550° F., of the bonds made with formulations of unmodified phenol resin, resin with 0.7 per cent benzene sulfonic acid, resin with 0.7 per cent benzene sulfonic acid and 5 per cent hexamethylenetetramine, and resin with 1.5 per cent aminopropyl morpholine, there were brown spots characteristic of thermal deterioration in the adhesive bonds given a precure of 15 minutes at 275° F.

Increased Discoloration

This was indicated in the table by increased percentages of discolored areas in the bond. These spots were not noted in any of the bonds precured at 200° F. In all cases where significant spots of deterioration occurred, the joint strengths were significantly lower than bonds with little or no such spots except in the formulation with 1.5 per cent aminopropyl morpholine, which showed only a slight reduction in strength. Adhesive formulations with one per cent of phenol, 1.5 per cent pyridine, 1.5 per cent diethylethanolamine, and 1.5 per cent triethanolamine showed no spot deterioration at either condition.

The joint strength data considered with the appearance of the broken bonds show then that the resistance of this particular phenol resin to thermal degradation was not improved by the addition of either an acid, formaldehyde, or a primary amine (aminopropyl morpholine), but was improved by the addition of phenol and the mildly alkaline tertiary amines (pyridine, diethylethanolamine, and triethanolamine); however, triethanolamine had an adverse effect in reducing joint strength under all test conditions without contributing to visible thermal deterioration.

In tests made immediately at 500° F., the strength of bonds given a precure for 15 minutes at 275° F. were higher than those precured 30 minutes at 200° F. except when benzene sulfonic acid (B.S.A.), B.S.A. and hexa, and diethylethanolamine were used. The addition of an acid catalyst and formaldehyde to the adhesive resulted in no improvement in the resistance to thermal deterioration and greater loss in immediate strength at 500° F.; the addition of phenol and certain alkaline amine catalysts improved the resistance to thermal degradation as well as the resistance to thermal softening at elevated temperatures.

The results of these tests therefore indicate that the adverse effect of the higher precure temperature and long precure periods in reducing the resistance to thermal degradation and the immediate strength at

elevated temperatures could very likely be related to the composition and catalytic system of the phenol resin. The following hypothesis was postulated for these observed adverse effects of excessive precure:

The higher precure temperatures and longer precure periods presumably cause excessive liberation of ammonia, which is probably present in the phenol resin either as the original catalyst or from the breakdown of hexamethylenetetramine, added as a latent curing agent, to make the adhesive system less basic or even slightly acid. Under such conditions of reduced alkalinity, the ratio of phenol to formaldehyde is known to be highly important in regulating the final degree of cure and the solubility and fusibility of the cured polymer.

Carswell(2) report that when phenol is present in excess, the resin will cure to a completely insoluble and infusible form in the presence of an alkaline catalyst, but under similar conditions a soluble and fusible polymer is formed with an acid catalyst. This hypothesis could then explain the lower strength of bonds at elevated temperatures as a result of the more extensive precure periods.

The explanation for the occurrence of spots of thermal deterioration in the adhesive is more obscure. However, since the thermal deterioration was found to persist under acid catalyst condtions and not under alkaline conditions when a high temperature precure was employed, the cause of thermal deterioration may be associated with an incomplete crosslinking reaction and the formation of some type of thermally unstable compound or group attached to the polymer chain under slightly acid or even nearly neutral curing conditions. The thermally unstable compounds or groups that are formed could then conceivably act as nuclei to trigger the deterioration of the adhesive during heat aging.

Further work is needed to more completely resolve the problem of the effect of precure on the resistance of an adhesive to thermal deterioration. However, the present study has indicated that the real explanation may be found in the composition and catalyst system of the phenol resin, which if completely understood could result in the development of metal-bonding adhesives with greatly improved heat resistance. This suggests the desirability of investigations of varous types of phenol resins as heat-resistant adhesives for metal bonding.

4—Deterioration of stainless steel bonds

The performance of a phenol-epoxy type adhesive, FPL-891, in the preliminary work on this project in bonding aluminum was found to differ in many respects from that in bonds of stainless steel. The data in Table I showed that the type of surface preparation and the atmosphere of exposure were both highly important variables affecting the thermal resistance of the adhesive bond in stainless steel.

These data showed that for stainless steel the sulfuric acid-oxalic acid method (Method B, Appendix) of surface treatment gave better initial bond strengths and better thermal resistance properties than the sulfuric acid-sodium dichromate method (Method A, Appendix). The generally inferior performance of stainless steel bonds as compared to the aluminum bonds in these tests indicated quite definitely that the stainless steel contributed in some way to the degradation of the adhesive bond.

In further work on bonding of stainless steel the effect of various lengths of time of aging, ranging from one hour to 200 hours at 550° F. was investigated on lap shear specimens of 0.20-inch T302, ½ hard stainless steel bonded with adhesive FPL-878. The results of these tests at room temperature after aging are shown in Figure 5 along with similar data on bonds of 0.064-inch 24ST-3 clad aluminum alloy.

The aluminum surfaces were prepared for bonding by the standard sulfuric acid-sodium dichromate (Method A, Appendix). The stainless steel was prepared by treating with sulfuric acid-oxalic acid (Method B, Appendix), since previous work had shown these methods to be the most suitable for these two metals. In the bonding process on both metals, a precure of 30 minutes at 200° F. was employed to reduce to a minimum the effect of precure on thermal resistance.

Strength Losses at 500° F.

Bonds of both metals showed significant losses in strength after the first hour of aging at 550° F. The aluminum bonds, however, showed very little further loss in continued aging up to 200 hours. The strength of the stainless steel bonds, on the other hand, continued to decrease sharply with time until nearly all strength was lost after 48 hours of aging at 550° F. The drop in strength of the steel bonds with time was directly related to increases in the areas of darkened or discolored adhesive. This discoloration was first observed in the broken joints around the edges of the lap joints exposed for short periods and then progressed inwardly on longer exposure until it included the entire bonded area.

There was no visible evidence in the aluminum bonds to indicate such progressive thermal degradation of the adhesive. Neither was the degradation of the adhesive in stainless steel bonds similar to the discolored spot-type deterioration observed in aluminum joints that were precured under adverse conditions, as previously described. These data and observations on the FPL-878 adhesive, like the data on FPL-891 adhesive previously cited, pointed to the stainless steel surface itself or to oxides of some component of the steel surface as possible agents for influencing the deterioration of the phenol-epoxy resin adhesives under heat aging. At least two possible mechanisms for this effect could be postulated:

(1) The metal surface itself may be chemically active and may influence the adjacent organic adhesive film catalytically. Presence of adsorbed ions on the metal surface and of alloying elements may be of particular importance in such catalytic effects on the adhesive film. This was one reason chelating agents and other stabilizers were considered in the earlier development of heat-resistant adhesives at this Laboratory (*1*).

(2) The nature of the metal surface may be particularly important because of physical and chemical changes in the metal layers themselves during the heat aging of the bond. There is little doubt that the metal is covered with a surface oxide

coating. In the case of aluminum this oxide layer is believed to form rapidly and rather completely by the time bonding is completed and to possess a rather high cohesive strength. It is then probable that relatively little change in the amount or form of oxide coating occurs on heat aging of the bonds.

Based on the relatively slight difference observed in aging aluminum bonds in air and in nitrogen (Table 1), it might be inferred that the oxide coating on aluminum retards entry of oxygen from the air quite effectively and thus minimizes further oxidation of the aluminum and of the adhesive film on heat aging. However, in the case of stainless steel, the formation of an oxide coating may be slower and quite incomplete when the bond is formed and may continue to a considerable extent during subsequent heat aging of the bond.

This further oxidation may result in a more porous film, perhaps of lower cohesive strength than that formed on aluminum. Such a porous film could be expected to permit greater entry of oxygen into the metal and to the adhesive film, which would result in progressive oxidation of either the metal or the adhesive film on heat aging. The lower cohesive strength of the oxide layer could also contribute to lower over-all bond strength after heat aging.

Further work in bonding stainless steel was directed towards exploring these hypotheses, particularly to investigate methods of preparing stainless steel surfaces for bonding that would result in more thermally stable bonds. Adhesive FPL-878 (Appendix) was used throughout in these studies to bond 0.020-inch, ½ hard, T302 stainless steel. Bonds were precured for 30 minutes at 200° F. and then pressed at 320° F. for 60 minutes at 50 pounds per square inch bonding pressure. Specimens had an overlap of 0.5 inch.

The results of aging tests at 500°, 530°, and 550° F. on stainless steel bonded with FPL-878 adhesive and prepared for bonding by various methods are presented in Tables VII, VIII and IX.

The tests of bonds aged at 500° F. for 48 hours (Table VII) and then tested at room temperature showed that a chemical treatment by Method D consisting of hydrochloric acid, hydrogen peroxide, and formalin was superior to Method B (sulfuric acid-oxalic acid) and to Method B followed by Method A (sulfuric acid-sodium dichromate). Heat treating the chemically cleaned surfaces by heating for one hour at 500° F. to dry the surface completely and remove any residual acid from the surfaces showed marked improvement only with Method B (Groups 1, 2, and 3).

Causes of Improvement

The improvement noted with Method B by heating at 500° F. was probably not a result of the removal of water and adsorbed acids from the surface, but more likely the result of the formation of a stable oxide layer on the metal surface by thermal oxidation since this chemical treatment is a strong reducing agent and could have conceivably removed the naturally occurring oxide from the stainless steel surface. Heating the treated surfaces for 30 minutes at 1200° F., however, showed no more improvement than heating at 500° F.

In groups 13, 14, and 15, the stainless steel surfaces, which were first treated with sulfuric-oxalic acid followed by the sulfuric-dichromate solution, were modified by either sprinkling with aluminum powder (13) or brushing with a solution of manganese naphthenate (6 per cent manganese) (14), or cobalt naphthenate (6 per cent cobalt) (15). These metallic naphthenates were in solutions in organic solvents as supplied by the manufacturer for use as wood preservatives or paint dryers. They were reported to contain 6 per cent of the appropriate metal ion by weight.

These naphthenates were used simply as a convenient means of applying the desired metals to the stainless steel surface. These coated sur-

Figure 5—Effect of Aging at 550° on Strength of Aluminum and Stainless Steel Bonded with FPL-878 and Tested at Room Temperature

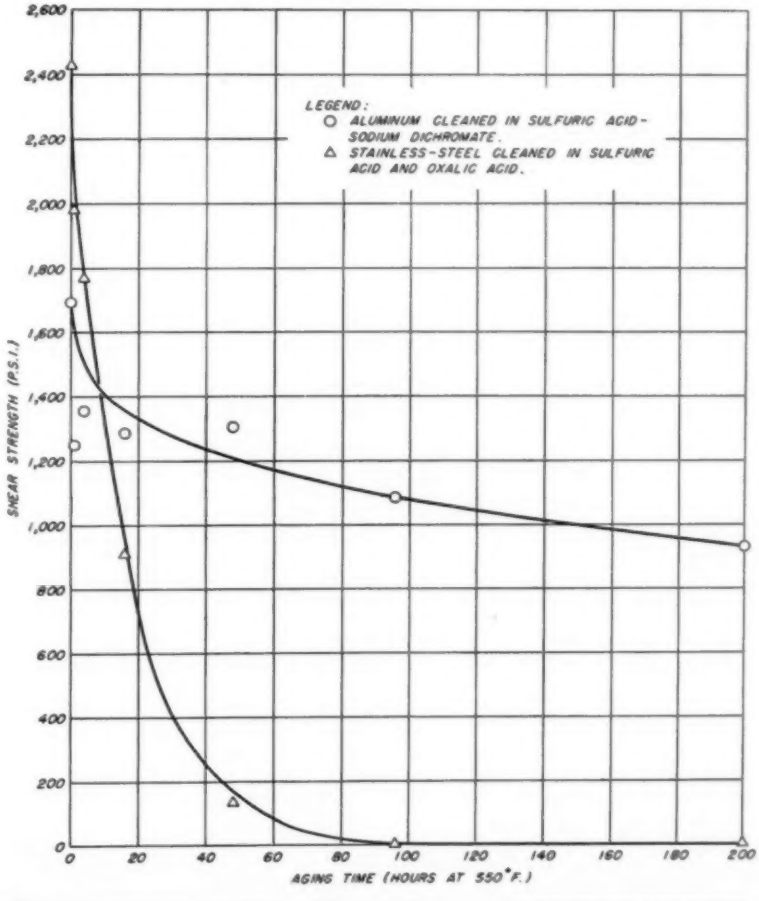

Table VII—Shear Strength Values After Aging at 500° F. of Bonds Made with FPL-878 on T302 Treated Stainless Steel

Group	*Surface Treatment*[1]	*Heat Treatment of Surface*	*Shear Strength at 80° F. After 48 Hours at 500° F.*[2]
			P.s.i.
1	B	None	98
2	B	60 minutes at 500° F.	582
3	B	30 minutes at 1200° F.	550
4	B and A	None	440
5	B and A	60 minutes at 500° F.	540
6	A	30 minutes at 1200° F.	484
7	B and C	60 minutes at 500° F.	100
8	D	None	854
9	D	60 minutes at 500° F.	984
10	B, then 60 minutes in water at 212° F.	None	324
11	B, then 60 minutes in 5 per cent CrO_3 at 212° F.	None	0
12	1, then 60 minutes in 2 per cent 3-hydroxy-2-naphthoic acid at 212° F.	None	364
13	B, A, then coating of aluminum powder	30 minutes at 1200° F.	550
14	B, A, then 1 coat of manganese naphthenate	30 minutes at 1200° F.	304
15	B, A, then 1 coat of cobalt naphthenate	30 minutes at 1200° F.	1,114

Notes: [1]See Appendix for description and composition of the various methods used in surface treatment. [2]Each value is the average for 3 specimens.

Table VIII—Shear Strength Values After Aging at 530° F. of Bonds Made with FPL-878 on T302 Treated Stainless Steel

Group	*Surface Treatment*[1]	*Coating*[3]	*Shear Strength at 80° F. After 48 Hours at 530° F.*[2]
			P.s.i.
16	B and A	cobalt naphthenate	192
17	B and A	iron naphthenate	392
18	B and A	lead naphthenate	60
19	B and A	zinc naphthenate	606
20	B and A	cobalt nitrate[4]	60
21	B and A	cobalt chloride[4]	20
22	D	none	380
23	D	cobalt naphthenate	362
24	D	zinc naphthenate	520
25	D	lead naphthenate	90
26	D	copper naphthenate	0
27	D	nickel naphthenate	246

Notes: [1]See appendix for description and composition of the various methods used in surface treatment. [2]In each case the coating was applied by brush to the chemically treated surfaces and then heated to 1200° F. for 30 minutes and cooled before the adhesive was applied. [3]Each value is the average for 3 specimens. [4]The treated metal surfaces were immersed for 60 minutes in a boiling 5 per cent solution and then heated to 1200° F.

faces were then fired at 1200° F. for 30 minutes to remove the organic components and leave the metallic component of the solution possibly combined with the stainless steel on the surface. These tests revealed that aluminum powder (13) had very little advantage over firing alone (3), the manganese had possible adverse effect (14) and cobalt (15) improved the resistance of FPL-878 to thermal degradation to a very marked degree. The effectiveness of the fired cobalt naphthenate surface in reducing thermal degradation at 500° F. was considered to be a highly significant step toward improved bonds in stainless steel. These results indicated the desirability of further study of the use of other metallic ions to stabilize the stainless steel surface against thermal aging.

In subsequent work on bonding stainless steel, various metal naphthenates were used to treat the steel surfaces and an evaluation of their effectiveness in reducing thermal degradation of the adhesive was made at 530° F. These data are shown in Table VIII. Comparison of the results on cobalt-treated surfaces, group 16 (Table VIII) with group 15 (Table VII) showed that an increase of 30° in aging temperature had a marked adverse effect on the thermal resistance of the stainless steel bond with FPL 878 adhesive.

Higher Bond Strengths

Surfaces coated with iron naphthenate (17) had significantly higher bond strengths after heat aging than did the cobalt-treated surfaces (16). Surfaces treated with lead naphthenate (18) were exceptionally low in strength and most likely indicated that the lead residue, presumably an oxide, was a definite catalyst to thermal degradation of the adhesive.

A treatment with zinc naphthenate (19), on the other hand, was superior to the other metallic treatments and indicated a definite stabilizing effect. Methods involving immersion of the acid-cleaned surfaces in boiling 5 per cent solutions of cobalt nitrate (20) and cobalt chloride (21) were much inferior to other methods.

Another series of tests (22-27) employed the more promising acid process of hydrochloric acid, hydrogen peroxide, and formalin (Method D, Appendix) as the initial treatment of the steel surfaces. The metal was then coated with various metal naphthenates and fired at 1200° F. before cooling and bonding. These tests again pointed out the superior performance of the zinc-treated surfaces (24) over cobalt (23) and the very adverse effect of treating the surfaces with either lead or copper. Results indicated that the effectiveness of the metal treatment on the heat resistance of the bond may be related to the type of chemical treatment employed initially in preparing the steel surfaces.

Results of further study of the resistance of stainless steel bonds to aging at 550° F. are shown in Table IX. In this work a more extensive study was made of steel surfaces treated with naphthenates of zinc, cobalt, calcium, iron, and nickel which were fired at 1200° F. for 30 minutes and cooled prior to bonding

with FPL-878 adhesive. The superiority of the zinc naphthenate treatment in reducing the thermal degradation of the adhesive compared to other metallic treatments is apparent from these data.

The effect of initial chemical treatment of the surface on the subsequent effectiveness of the zinc surface is also apparent from the results of group 34 compared with groups 40, 42, and 44, which indicate that oxidizing chromate solutions, such as those used in Methods A and E, are more favorable than a hydrochloric acid oxidizing solution, such as that used in Method D. Results of tests on groups 44 and 42 show that one brush coat of zinc naphthenate was as effective as two coats. Zinc napthenate was also effective in two-coat applications where the first coat was of cobalt (46) or nickel (49), but was less effective with calcium (52).

One-coat applications of certain mixtures of several naphthenates were promising, particularly a mixture of zinc and nickel naphthenates (51) and a mixture of iron, nickel and zinc naphthenates (61). The performance of bonds to stainless steel prepared with mixtures of the metallic naphthenates would probably be worthy of further investigation, especially since little is known of the resistance of a bond of a stainless steel surface treated with zinc to attack by salt water, water, and various aircraft fuels and lubricants.

The examination of the bonds of stainless steel with the zinc-treated surface after aging and testing disclosed that there was still considerable degradation or discoloration of the adhesive occurring around the edges of the lap joints and along the branches of the tunnel-like voids, and in some cases in spots as was observed in bonds to aluminum (Figure 4, B, C, and D) prepared under adverse precure conditions.

Zinc Naphthenate Dip

This observation indicated that the thermal resistance of the adhesive in the stainless steel bond might be improved by dipping the metal in zinc naphthenate, instead of brushing, to more effectively coat the edges of the metal as well as the faces and thus retard any thermal deterioration which might be occurring at the edges. The type of failure with the presence of spots of discolored adhesives also indicated that the optimum precure conditions were probably not being employed. The results of further tests to study such a dipping treatment and various precure conditions on the resistance of FPL-878 adhesive to thermal deterioration are shown in Table X.

These results showed improved resistance to thermal aging by the dipping process and precure at a slightly lower precure temperature compared to groups 44 and 45 in Table IX. Applying the zinc naphthenate by dipping individual metal strips prior to firing and then bonding instead of brushing appeared to reduce the thermal deterioration around the edges of the bonded area and the lower precure temperature of 180° F. eliminated all of the spot-type thermal deterioration in adhesive bonds.

The joint strength of 900 to 1000

Table IX—Shear Strength Values After Aging at 550° F. of Bonds Made with FPL-878 on T302 Treated Stainless Steel

Group	*Surface Treatment*[1]	*Coating*[2]	*No. of Coats*	*Shear Strength at 80° F. After 48 Hours at 550° F.*[3]
				P.s.i.
28	B	none		132
29	D	none		134
30	D	cobalt naphthenate	1	133
31	D	iron naphthenate	1	35
32	D	calcium naphthenate	1	127
33	D	nickel naphthenate	1	350
34	D	zinc naphthenate	1	83
35	D and A	none	1	114
36	D and A	cobalt naphthenate	1	40
37	D and A	iron naphthenate	1	236
38	D and A	calcium naphthenate	1	350
39	D and A	nickel naphthenate	1	40
40	D and A	zinc naphthenate	1	660
41	abraded	zinc naphthenate	2	100
42	E	zinc naphthenate	2	504
43	D and E	none		70
44	D and E	zinc naphthenate	1	570
45	D and E	zinc naphthenate	2	580
46	D and E	cobalt naphthenate and zinc naphthenate	1 each	724
47	D and E	zinc naphthenate and cobalt naphthenate	1 each	224
48	D and E	cobalt-zinc naphthenate mixture	1	492
49	D and E	nickel naphthenate and zinc naphthenate	1 each	610
50	D and E	zinc naphthenate and nickel naphthenate	1 each	424
51	D and E	nickel-zinc naphthenate mixture	1	690
52	D and E	calcium naphthenate and zinc naphthenate	1 each	246
53	D and E	zinc naphthenate and calcium naphthenate	1 each	124
54	D and E	calcium-zinc naphthenate mixture	1	140
55	D and E	iron-zinc naphthenate mixture	1	340
56	D and E	cobalt-nickel-zinc naphthenate mixture	1	320
57	D and E	cobalt-calcium-zinc naphthenate mixture	1	500
58	D and E	cobalt-iron-zinc naphthenate mixture	1	556
59	D and E	calcium-iron-zinc naphthenate mixture	1	262
60	D and E	calcium-nickel-zinc naphthenate mixture	1	306
61	D and E	iron-nickel-zinc naphthenate mixture	1	702
62	D and E	iron-nickel-calcium-zinc naphthenate mixture	1	334
63	D and E	iron-nickel-calcium-cobalt-zinc naphthenate mixture	1	320

Notes: [1]See appendix for description and composition of surface treatments. [2]Coatings applied by brush and then heated to 1200° F. for 30 minutes before application of the adhesive. Where more than 1 material was applied the first material mentioned was applied first to the stainless steel surface. [3]Each value is the average of 4 to 8 specimens.

Table X—Effects on Stainless Steel Bonds Made with FPL-878 Adhesive of Dipping Metal in Zinc Naphthenate

Surface Treatment[1]	*Coating*[2]	*Precure Temperature °F.*	*Time Min.*	*Bonding Pressure*	*Shear Strength at 80° F. After 48 Hrs. at 550° F.*[3] *P.s.i.*
D and E	zinc naphthenate	200	30	25	896
D and E	zinc naphthenate	200	30	50	968
D and E	zinc naphthenate	180	25	25	911
D and E	zinc naphthenate	180	30	50	1,080

Notes: [1]Methods of surface treatment are described in appendix. [2]After 1 dip coating the surfaces were heated to 1200° F. for 30 minutes then cooled before the adhesive was applied. [3]Each value is the average of 8 specimens.

pounds per square inch after aging, as was obtained in several of these conditions with zinc naphthenate, represents a very significant improvement in the resistance of stainless steel bonds to aging at elevated temperatures over that obtained by various chemical treatments alone as were employed in earlier studies on this project.

Time did not permit further study and refinement of the zinc naphthenate treatment of the stainless steel surfaces for bonding. It is quite likely that a study to determine the effect of such variables as the thickness of the zinc coat, firing temperature, firing time, initial chemical treatment, and mixtures of zinc naphthenate with other metal salts would result in even greater improvement in the resistance of stainless steel bonds to heat aging. Modification of the steel surface with other metals and by other processes might also be promising as means of improving thermal stability of the adhesive bonds.

The study on the thermal deterioration of bonds of stainless steel indicated that the principal cause of deterioration was probably the adverse catalytic effect of the oxides of stainless steel on the adhesive. The porosity of the oxide surface of the steel to oxygen was probably also a factor. This adverse effect could not be significantly reduced by forming a stable oxide layer on the surface by the usual chemical treatments in water solution or by heat aging of the metal alone at temperatures as high as 1200° F. prior to bonding.

There was evidence that even after such measures were taken to form an oxide layer on the surface, further oxidation of the metal took place during heat aging, which resulted in deterioration of the adhesive. This further oxidation apparently occurred first at the edges of the bonded area that were accessible to air to form a porous oxide that permitted the entry of air and progressive oxidation of the metal into the center of the bonded area.

The adverse effect of the stainless steel surface on the thermal resistance of the adhesive was reduced to a marked degree by a zinc coating; this coating was formed on the surface by treating it with zinc naphthenate and firing at 1200° F. to remove organic components and presumably to form zinc oxide. This type of zinc coating thus apparently stabilized the steel surface against further oxidation, which would cause subsequent deterioration of the adhesive, by forming an impervious jacket over the steel and retarding the entry of air into the steel.

This reduction in oxidation of the steel may indirectly have also reduced an unfavorable catalytic effect of the normal oxidized steel surface on the thermal degradation of the adhesive itself.

5—Effect of aging under stress on bond strength

This phase of the study was intended to investigate the effects of the physical orientation of the molecular chains of the adhesive polymer in the cured bond on joint strength of lap joints at several conditions. The orientation of the molecular chain was attempted by aging bonded lap joint specimens at an elevated temperature in a stressed or loaded condition. The results of this work also gave an insight into the thermoplastic properties of phenol-epoxy resin adhesives, their resistance to creep, and the performance of bonds in conditions closely representative of service conditions.

The study was conducted on 0.5-inch lap joints of 0.064-inch 24ST-3 clad aluminum alloy bonded with FPL-878 adhesive (Appendix). The metal was prepared for bonding by Method A (Appendix). The adhesive was precured 15 minutes at 275° F., cured 60 minutes at 300° F. at 50 pounds per square inch, and postcured 16 hours at 275° F. The large number of individual specimens, cut from various panels, were randomly inserted into each of several representative groups for the following tests.

Shear tests were made at each of several temperatures on specimens aged for 100 hours at 300° and 400°F., both unstressed and under a stress of 1500 pounds per square inch. The results of these tests are shown in Table XI.

The results of these tests showed that aluminum bonds of FPL-878 adhesive, that had been aged at 300° or 400° F. for 100 hours under a stress of 1500 pounds per square inch, were approximately 30 per cent higher in strength at —70° F. and at 80° F. than specimens that were aged at these temperatures in an unstressed condition. At a test temperature of 300° F. the aged-stressed specimens were about 10 per cent higher in strength than the aged specimens under no stress. At a test temperature of 600° F. there appeared to be no significant differences in the stressed and unstressed specimens.

With but one exception the strength values of aged-stressed specimens were higher than the controls at test temperatures of —70°, 80°, and 300° F. In all cases at these test temperatures the strength values of specimens aged without stressing were lower than the control strength values.

The increases of strength values in bonds tested at 600° F. after aging probably indicated the effect of additional curing of the adhesive during the aging period, particularly when aged at 400° F. and showed no ad-

vantage in stressing of the bond during aging.

No creep was observed in any of the bonds by microscopic observation of scratch lines on the sides of the specimens while under load during the 100-hour aging and loading period at 300° F. and 400° F.

Polymer Chain Orientation

These data showed an apparent advantage in stress-aging bonds at an elevated temperature. The increase in strength could presumably have been produced by more favorable orientation of the polymer chains of the adhesive to relieve internal stresses imposed upon it by the eccentricity of loading in a lap-joint specimen, differences in the thermal expansion or contraction of the metal and the adhesive, and any internal molecular forces developed between polymer chains during the random orientation of these chains while heat was being applied in the initial bonding process. The joints may also have increased in strength by virtue of the rearrangement of the metal crystal structure to relieve stresses within the metal.

Table XI—Effects of Heat Aging for 100 Hours at 300° and at 400° F. in Unstressed and Stressed Conditions on Aluminum Lap Specimens Bonded with FPL-878

Test Temperature °F.	*Controls[1] P.s.i.*	*300° F.[2] Stressed[3] P.s.i.*	*300° F.[2] Unstressed[4] P.s.i.*	*400° F.[2] Stressed[5] P.s.i.*	*400° F.[2] Unstressed[6] P.s.i.*
−70	1,648	2,116	1,514		
80	1,740	2,176	1,592	2,242	1,650
300	2,062	2,290	2,046	1,840	1,610
600	374	440	400	824	900

Notes: [1]Specimens not aged or stressed but tested immediately after reaching temperature equilibrium as shown. Each value is the average of 5 specimens. [2]Each value is the average of 3 specimens: [3]Specimens aged at 300° F. for 100 hours at a shear stress of 1,500 pounds per square inch. [4]Specimens aged at 300° F. for 100 hours in an unstressed conditions. [5]Specimens aged at 400° F. for 100 hours at a shear stress of 1,500 pounds per square inch. [6]Specimens aged at 400° F. for 100 hours in an unstressed condition.

6—*Effect of high-low temperature cycle*

Another possible source of physical deterioration of an adhesive bond in service at elevated temperatures is the internal stressing of the adhesive that comes about due to the differential thermal expansion and contraction of the metal and the adhesive. To study this effect a group of specimens matched with the specimens used in the study on the effect of aging under stress was employed. A group of 0.5-inch lap-joint specimens of 0.020 inch thick, T302, ½ hard stainless steel was also included in the study because steel has a coefficient of thermal expansion that is about one half that of aluminum. These specimens were bonded with FPL-878 adhesive by precuring for 30 minutes at 200° F. and were then cured at 320° F. for 60 minutes under 50 pounds per square inch. The stainless steel was prepared for bonding by Method B (Appendix).

The specimens were exposed to a cycle of 45 minutes at 450° F. and 45 minutes at −55° F. and were tested at −70°, 80°, and 450° F. before cyclic exposure and after 25, 50, and 100 cyclic exposures. The periods of exposure in this cycle were shown to be sufficient to allow the temperature of the metal to come to equilibrium and yet not result in any excessive exposure at either temperature in any one cycle.

The specimens were changed from the hot to the cold phases of the cycle and vice versa immediately without allowing to cool or warm to room temperature except overnight and over weekends when they were kept at 80° F. The results of these tests are shown in Table XII.

The results of tests at −70° F. and 80° F. show a loss in joint strength in both aluminum and stainless steel bonds after 25 cycles. In the case of aluminum bonds there was no further loss in joint strength by longer exposure to 50 and 100 cycles. The bonds of stainless steel, however, showed further losses in strength after 50 cycles and very marked losses in strength after 100 cycles.

Table XII—Effect of High-Low Temperature Cyclic Exposures on Aluminum and Stainless Steel Lap Specimens Bonded with FPL-878

Type of Metal	*Number of Cycles[1]*	*Average[2] Shear Strength at: −70° F. P.s.i.*	*80° F. P.s.i.*	*450° F. P.s.i.*
Aluminum alloys—24ST3	0	1,704	1,586	1,024
	25	1,410	1,096	1,446
	50	1,534	1,100	1,336
	100	1,530	1,248	1,346
Stainless steel—T302, ½ hard	0	2,782	2,748	1,220
	25	1,960	2,074	1,534
	50	1,826	1,874	1,548
	100	1,046	1,316	916

Notes: [1]One cycle consisted of 45 minutes exposure to 450° F. then 45 minutes to −55° F. [2]Each value is the average of 6 test specimens.

Strength Losses Explained

These losses in strength in steel bonds are believed to be more likely due to thermal degradation of the adhesive as evidenced by higher percentages of discolored area in the bond with longer exposures rather than to continued stressing of the bond by the high-low temperature cycle. The initial drop in joint strength observed after 25 cycles in both types of specimens indicated

that the initial cure of the adhesive had been advanced to a higher degree by this exposure, which would result in embrittlement and loss in strength at −70° and 80° F.

The increase in joint strength on cyclic aging observed at 450° F., which may be associated with reduced thermoplasticity or increased cross linking of the adhesive, is a further indication of the advancement in the degree of cure of the adhesive by exposure to the high-low cycle. The marked loss in joint strength at 450° F. in stainless steel bonds after 100 cycles is again attributed to thermal degradation of the adhesive.

The data show little significant evidence of losses in joint strengths that may be attributed directly to thermal shock or adverse stresses imposed on the adhesive bond by differences in thermal expansion of the metal and the adhesive. It is felt that any relationship that may exist between the thermal expansion of the adhesive and adherend is probably very complex for it is known that the thermal coefficient of expansion varies at different temperature ranges and is also very likely to change as other physical properties, such as curing of the resin or changes in the metal itself, are changed with heat aging.

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(2) Carswell, T. S., "Phenoplasts, Their Structure, Properties, and Chemical Technology," Interscience Publishers, Inc., N.Y., 1947.

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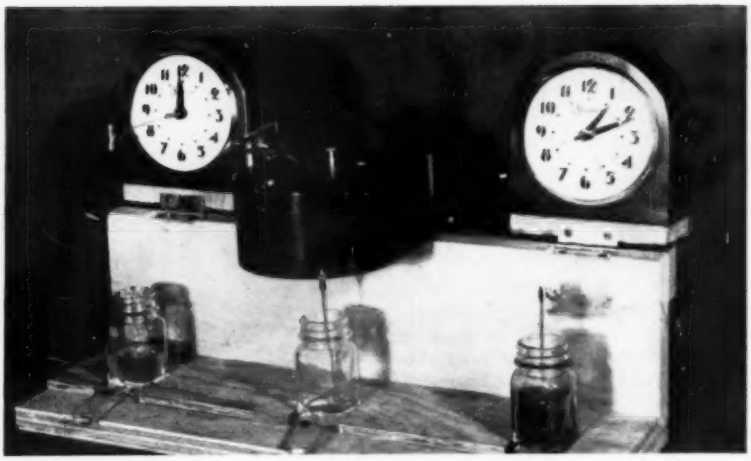

Three clock-viscometers are hinge-mounted on a wooden platform. The center unit is in use; the rotor of the clock on the right is stopped in the sample after 72 minutes.

Timely Device Clocks Pot Life of Adhesives

Do-it-yourself viscometers made from modified electric clocks are used by lab technicians to measure gel time

For estimating the pot life of adhesive samples being tested, Bjorksten Research Laboratories, Inc., Madison, Wisc., has developed a simple viscometer made from a modified electric clock. The ingenious device records the gel time of an adhesive to the nearest minute.

To construct this inexpensive testing unit, Bjorksten lab technicians removed the protective glass from the face of an electric clock and soldered a chuck to the shaft which operates the second hand. Expendable rotors, or paddles, are inserted into the notched end of the chuck. These rotors, made of 0.087 aluminum wire, are formed into an S-shaped loop at one end and flattened at the end which fits into the chuck.

Three such clock viscometers are hinge-mounted on the top of a small wooden testing platform. The base of the platform has three grooved spots into which the adhesive specimen jars are fitted. A simple wooden locking device (see photo) keeps the jars firmly in place during testing.

To measure the pot life of a newly developed adhesive, the clock-viscometer is tilted forward so that the aluminum rotor is inserted into the adhesive sample. The hands of the clock are set at 12 sharp and the electric motor started.

When the mixture gels, it prevents the rotor from turning and this in turn keeps the hands of the clock from advancing. Gel time, or pot life, of the adhesive can then be easily read off at a glance.

The clock-viscometer has aroused considerable interest because of its relative simplicity. James E. Henning, vice-president of Bjorksten, reports that no similar units are commercially available at present. "We have suggested to all inquirers," he adds, "that they build their own. Several have already done so."

Types of Bonds Involved in Adhesion

PART I of an investigation into the principles of adhesion pointing to the possibility of producing stronger bonds by tailoring the organic adhesive molecules to the application

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Many different adhesives, some closely related in molecular structure and others of radically different natures, are known and used today for the purpose of bonding a variety of solid materials together. Extensive expenditures of research effort have gone into the development, compounding, and testing of these many high polymeric materials striving toward, and succeeding in, attaining stronger joints, known as adhesive bonds, between dissimilar phases. Adhesives have been studied extensively and modified in many ways to obtain bonds having desirable properties for specific industrial applications. The adhesives industry and technology of today are the result of these activities.

As is so frequently the case in a rapidly expanding field of research activity, only limited time has been allotted to investigations designed to reveal why adhesives adhere. Yet attainment of maximum adhesion between adhesives and other materials depends to a considerable degree upon an understanding of the forces involved in this union because such knowledge can make possible the tailoring of organic adhesive molecules to produce stronger bonds.

Though a variety of different mechanisms have been proposed for the interaction at the interface between an adhesive and an adherend which results in adhesion, four more or less recent findings seem to require that we examine more carefully these earlier postulates concerning the nature of the interfacial bond. Correlation of these recent findings leads directly to the conclusion that there are usually very few points of interaction between a clean solid surface and an adhesive.

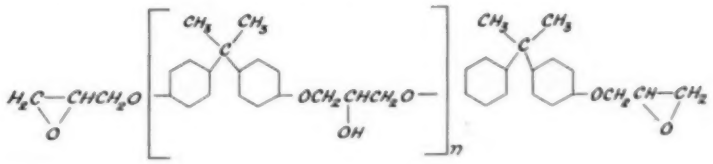
If this is the case, it follows that the forces of attraction must be very strong, since strengths of adhesion frequently are high. Calculations of Simha, Frisch, and Eirich (*1*) lead to the conclusion that only a small fraction of the active groups of a polymer chain can be expected to be anchored to the surface of an adherend when the polymer is deposited from dilute solution. Ullman (*2*) discusses experimental results on adsorption of polymers from solution, which support the theoretical work of Simha and co-workers, and describes the architecture at and near the solid-polymer interface on the solution side. The qualitative model is one of coiled, laterally compressed polymer chains anchored on the solid by a small fraction of the active groups in the polymer molecule, the un-anchored segments of the chain extending into the solution phase. He also recognizes that on a surface that is rough, molecularly, there are regions containing adsorption sites that are not available to large polymer molecules due to geometrical blocking.

Taylor and Rutzler (*3*) studied the fit of straight polyethylene and polyvinyl chloride chains on plane, ordered surfaces of metal oxides and concluded that only a fraction of the total adsorption site on the surface can participate in adhesion. When the interface consists of coiled chains of polymers and rough, polycrystalline oxide, as in the actual case of adhesion of a polymer to a metal surface, only a very minor fraction of the bonding sites can be involved in anchoring the polymeric adhesive to the adherend.

Glazer (*4*) assumes that an epoxy resin having the structure shown in Figure 1 adheres to wood and to metals as a result of an interaction between the hydroxyl group of the polymer and hydroxyl groups or oxide ions of wood and metal surfaces respectively. Measurement of the configuration of this polymer on the surface of water, where it is anchored by hydrogen bonding between hydroxyl groups of the polymer and water molecules, was made by Glazer and shows that the smallest possible area into which two hydroxyl groups can be compressed is between 51 and 55Å².

If one calculates the number of oxide ions in 51-55Å² in the plane,

Fig. 1—Structure of the Epoxy Resin Studied by Glazer



Note: n=1.8

ordered surface of titanium or iron, using the lattice parameters shown by Taylor and Rutzler, the result is that only 13-17 per cent of the oxide ions in the metal surface can participate in the bonding with this typical epoxy resin, assuming an exact fit. Even a smaller fraction of the oxide ions would be involved if the fit of hydroxyl groups to oxide ions were not perfect or if the surface of the metal were rough. On the other hand, if the polymer were extended on the surface of the metal, as it can be on the surface of water and as it seems likely to be on a metal surface, it would occupy 65Å²; then only about 10 per cent of the oxide ions could be involved in the bonding under conditions of ideal fit.

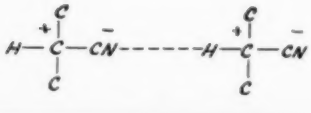
Other evidence for the importance of the geometrical interfacial arrangement of adhesive molecules with respect to the surface of the adherend and its relation to bond strength is given elsewhere (*36*).

Types of Forces Active

Various workers have accounted for the phenomenon of adhesion in terms of several different types of interfacial interaction between adhesive and adherend such as, for example, covalent interactions between vulcanized rubber and brass (*5*) (*6*) and between alkyd resins containing organic acids and metals (*7*), van der Waals forces acting in many systems of adhesives and adherends (*8*) (*9*), hydrogen bonding between cellulose and adhesives containing carboxyl groups (*10*), partially covalent and partially ionic bonds between silicon and the oxygen ion in the adhesion of silanes to glass (*11*), electrostatic interaction between charges transferred across the interface between adhesive and adherend (*12*) (*13*), and others.

Most generally, however, van der Waals forces, including the dispersion forces of London, have been invoked to explain adhesion because calculations of strengths of adhesion based on such a model generally show far greater strengths than can be realized experimentally. To let the question of the types of bonds involved in adhesion rest here is to ignore the probability that very few points on the surface of an adherend adsorb molecules of the adhesive very strongly—much more strongly, on a per site basis, than can be accounted for by van der Waals forces —and to reduce our studies of new adhesives and of modifications of known adhesives largely to a "cut-and-try" basis.

Fig. 2—Dipole-Dipole or Hydrogen Bond "Cross-Links" in Polyacrylonitrile



Any endeavor to select a series of adherends and adhesives and to assign, case by case, a single, definite mechanism to the interaction between the two must, in the present state of knowledge, be arbitrary in many of the selected systems. However, much stands to be gained from setting up any generalizations that are possible concerning the forces involved in the adhesive bond and then examining specific types of interactions that come into play in various systems. There are four generalizations that appear to express the present state of our knowledge concerning the kinds and strengths of bonds formed in adhesion. These may be stated in the following way:

(1) The cohesive strength of adhesives is due to van der Waals forces (dipole-dipole, dipole-induced dipole, and dispersion or instantaneous dipole forces) when the polymeric adhesive is not chemically cross-linked and due to a combination of ionic or covalent bonds and, in some cases van der Waals forces when the adhesive is cross-linked. In this discussion hydrogen bonds are considered to be due to strong van der Waals interactions.

(2) All cases of adhesion can be treated either as physical adsorption or chemisorption or a combination of the two with the interaction at each site being essentially wholly of one or the other type.

(3) The bonds between thermoplastic adhesives and thermoplastic adherends result from diffusion, under the influence of heat, and/or pressure, and/or a solvent, of the two phases into one another to form what may be termed an entanglement bond which owes its strength substantially to van der Waals forces.

(4) Powerful interactions of the order of 15-80 Kcal. per mole of bonds need to be postulated to account for strong adhesion because of the geometric arrangements at the interface which restrict severely the number of interactions with the adhesive per unit area of adherend surface, while very weak adhesion can be attributed to van der Waals forces. The basis for this generalization is discussed in earlier sections.

Cohesive Bonding in Adhesives

The nature of the forces that impart cohesive strength to high polymeric adhesives depends upon whether or not the chains of the adhesive molecule are chemically cross-linked and upon whether the cross-linking results in a three-dimensional space polymer, as in phenolic resins, or a two-dimensional net polymer, as in some styrene-divinyl benzene resins. The types of interactions involved are well-understood. For example, -C-O-C-, -C-C-C-, and -C-N-C- covalent bonds are present in polydiallyl phthalate, phenol-formaldehyde, and certain epoxy resins. When the cross-linking occurs at infrequent intervals along a chain, as in the net polymers, van der Waals forces are expected also to contribute to the total bonding along with the covalent interactions.

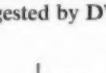
Other types of bonds are responsible for the cohesive strengths of carboxylic rubbers and polyacrylic acids, that are cross-linked by means of metals such as magnesium, and of polyacrylonitrile. The cross-links in the carboxylic polymers containing metals involve ionic or electrovalent bonds (*14*) resulting from reactions such as

$$R_1COOH + R_2COOH + M_g^{++}O \rightarrow$$

$$R_1COO^{-}M_g^{++}{}^{-}OOCR_2 + H_2O$$

where R_1 and R_2 represent portions of different chains.

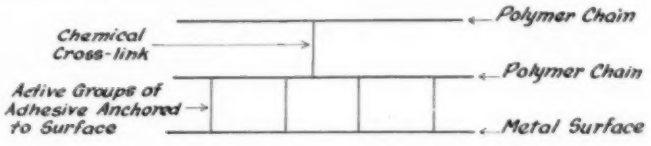
Here again, van der Waals forces between chains also are expected to contribute to the cohesion when the cross-links are far apart. Polyacrylonitrile probably is effectively cross-linked by another mechanism that has been suggested by D'Alelio (*15*). The



group of this polymer constitutes one of the most powerful dipoles encountered in organic chemistry, with the negative end of the dipole residing in the -CN group.

The hardness and infusibility of this resin probably is largely due to the dipole-dipole interaction shown in Figure 2 which is reinforced by dipole-induced dipole and dispersion force interactions. Since there is a -CN group on every other carbon

Fig. 3—Surface Geometry and Possible Bond Failure Location



atom of the polymer, many such interactions can take place between contiguous chains.

Though van der Waals forces such as these are relatively very weak compared with covalent and electrovalent bonds, the single interactions are expected to be additive to a marked degree, thus producing very strong cross-linking. In this connection, Bridgman (*16*) says that the dipole moment of polyoxydecanoic acid increases from 5 to 19 Debye units as the molecular weight increases from 905 to 13,900. A similar increase would be expected for polyacrylonitrile.

Adherend-Adhesive Interface

Strong bonds between an adhesive and an adherend require that the body of the adhesive shall possess high cohesive strength and that the adhesive shall be anchored strongly to the adherend. The assumption is made in the following discussion that the surface of the adherend is clean except for gases adsorbed from the atmosphere and held by van der Waals forces.

That the forces operating at a metal-adhesive interface are indeed very strong in many cases is suggested by a work of Patrick (*17*) who found that adhesive bond failure most likely does not take place at the interface even when, to all outward appearances, the nature of the break is adhesional with the metal surface exposed. On the basis of his work the probability is that in many cases of apparent adhesional failure either a monolayer of adhesive or fragments of the adhesive molecule are left on the surface of the adherend. If a monolayer of a cross-linked adhesive or molecular fragments of an adhesive are left on the surface of the adherend, when a bond fails, the strength of the anchoring to the adherend can be expected to be of the same order of magnitude as that of a covalent bond.

An exception to this result would be expected if the number of cross-links to the adhesive chain attached to the surface were many fewer than the number of bonds between adherend and adhesive as illustrated in Figure 3. In such a case the interaction between the polymer chain and the surface would be due to approximately the sum of the interfacial van der Waals interactions and this sum might exceed the strength of the one covalent bond between the first and second layers. If only fragments of adhesive molecules were left on the surface after failure of a bond, part of the electrical potential that has been observed to accompany apparent adhesional failure (*13*) can be attributed to the fragments.

There are, in general, two types of adsorption known as physical or van der Waals adsorption, in which the energies of interaction are about 10 Kcal./mole or less, and chemisorption involving surface chemical compound formation or an energetically equivalent interaction with interaction energies up to about 100 Kcal. mole. Now, strong bonding at the adherend-adhesive interface can result from a large number of weak interactions (van der Waals adsorption) between the two phases or from a few very strong interactions.

Consideration of the interfacial geometry leads to a preference for the latter mechanism in case of strong adhesion. When the adhesion is weak, as in the case when one attempts to bond metals by means of many silicones, polyformaldehyde, (*18*) and Delrin resin (*18*) with its bulky, chlorine-containing group, van der Waals adsorption is the probable mechanism involved in the bonding. On the other hand strong adhesion very likely results from chemisorption, or from other interactions that are energetically as powerful as those giving rise to ionic and covalent bonds.

The types of forces that may be involved in chemisorption, defined as high energy adsorption, are several in number. Those considered here are the forces involved in ionic, covalent and coordination bond formation with surface atoms, ion-dipole interactions with the ion generally being in a metal surface and the dipole being situated on the polymer chain of the adhesive, electrostatic forces arising from electrical charge transfer between adhesive and adherend, and the polarizability interactions of Weyl (*19*).

Based on these concepts of the nature of the adsorption that occurs in adhesive-adherend systems, we now proceed to discuss a number of specific cases. In many of the specific systems considered the interfacial interactions suggested undoubtedly are accompanied by other interactions. For example, an adhesive that is covalently bonded to a surface may also be anchored at some points by strong or weak van der Waals forces. The types of bonding that are proposed for various systems are those that seem most likely to occur and in most cases there is not proof that the selected type of interaction is correct.

Adhesion to Glass

A common practice is to represent the surface of glass as shown in Figure 4 with hydroxyl groups in the surface. Ordinarily water molecules will be adsorbed on the hydroxyl groups. The hydrogen atom is relatively positive, and can be exchanged for metal ions, and the oxygen is negative. A completely dehydrated surface of glass would be produced by removal of every other hydroxyl group and every other hydrogen atom, leaving alternating positive silicon atoms and negative oxygen atoms. On the basis of these oversimplified concepts of the nature of the glass surface we may inquire how various adhesives and primers can become attached to the surface.

A. Halosilanes and methacrylatochromic chloride—Assuming the structure shown in Figure 4, there seems to be agreement (*20*) (*21*) that after hydrolysis of a halosilane at the glass surface (containing adsorbed water) covalent -Si-O-Si- bonds are formed between the silicon atom of the silane and the oxygen ion of the glass surface. Since

Fig. 4—Idealized Glass Surface Structure with Chemisorbed Water

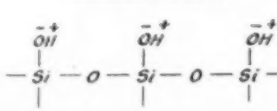
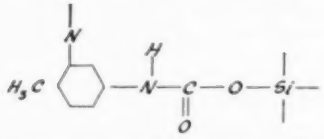
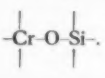


Fig. 5—Tolylene Diisocyanate Chemisorbed on Glass



some adsorbed water is required for the silane to become anchored (*21*) and water shows a Brunauer, Emmett, and Teller Type III isotherm (corresponding to weak adsorption) on at least one type of glass with no adsorption until 70 per cent of the water vapor saturation pressure is reached (*22*), the probability seems at best slight that a halosilane would be hydrolyzed and the free valences of the silicon thus produced all become satisfied by uptake of hydroxyl radicals from water before the interaction occurs.

The covalent bonds responsible for surface anchorage are, of course, very strong and are probably reinforced by having a partial ionic character. The adhesion of methacrylatochromic chloride to glass surfaces is said to result from covalent bonds (*20*) (*21*), having the structure



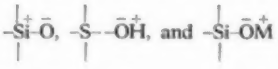
B. Tolylene diisocyanate—Skinner and co-workers (*20*) postulate that covalent bonds are involved in the adsorption of tolylene diisocyanate by a glass surface. The structure shown in Figure 5 is suggested by these workers.

C. Polyvinylbutyral and other compounds containing hydroxyl groups—Adhesion to glass is obtained using a number of different adhesives containing hydroxyl groups (*23*). Among these are epoxy, polyvinylbutyral, and a variety of rubber phenolic blends (*24*). While adhesion in these systems frequently is stronger than the glass itself, it is not apt to exceed around 2000 psi in tension and consequently must be classed as weak compared to metal bonds which frequently are in the 4,000-10,000 psi range of strength.

As a result, surface chemical reactions may not enter into the picture, hydrogen bonding between hydroxyl groups would seem, in the present state of our knowledge, to be the most plausible mechanism by which this group of adhesives bonds to glass, though ion-dipole interactions should not be ruled out.

That the ion-dipole mechanism may be involved here is indicated by Waine (*23*) who says that polyvinylbutyral does not adhere to glass unless one out of every ten hydroxyl groups of the vinyl chain is left intact after the acetal condensation reaction which is used to prepare the compound has been terminated. This result suggests again that the number of sites on the solid surface that participate in adhesion is relatively small and that interactions that are stronger than van der Waals forces should be postulated.

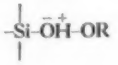
Even the qualitative understanding of ion-dipole interactions requires a knowledge of the nature of the surface of glass. Without going into an enumeration of the conditions under which the various possible surface groups on glass are formed and are stable, it is known that



structures exist in the surface, where $\overset{+}{M}$ denotes metal ions such as sodium or calcium ions. Eley (*25*) discusses ion-dipole interactions, and they are schematically represented for the systems in which we are interested in Figure 6.

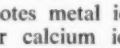
The freshly cleaved or machined surface of glass contains some oxide ions (Figure 6A) which can interact with water to form a hydroxylated surface (Figure 6B) which, in turn, can exchange hydrogen for metal ions (Figure 6C). Different orientations of adhesives containing –OH, –Cl, and $-NO_2$ groups are shown in the figure.

Were the glass surface formed in absence of water vapor, or were adhesive applied to the freshly formed surface, the polar groups of the adhesive would encounter surface sites like those shown in Figure 6A, with two interesting consequences. If the hydroxyl group of the adhesive were as ionizable as the hydrogen in water, an essentially ionic bond of the structure

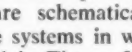


could form. Some phenolic blends containing readily replaceable hydrogen atoms possibly adhere by this mechanism and it is interesting to note that such blends are very strong adhesives that show bond failure in the glass (*26*).

The other consequence is that an adhesive containing a strong negative dipole, such as

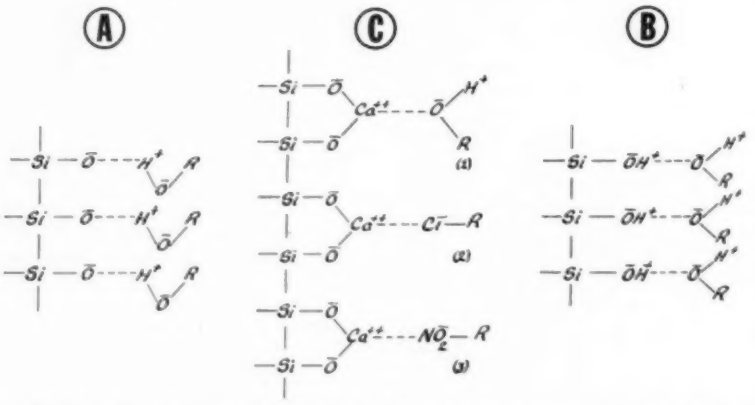


in polyvinyl chloride and



in nitrocellulose, would encounter a strongly negative surface on freshly machined glass and be repelled rather than adhered, since the size of the negative group would tend geometrically to block the positive end of the dipole of the adhesive from close

Fig. 6—Representations of Ion-Dipole Interactions



Note: A—Bonding to virgin glass surface. C—Bonding to a glass surface containing metal instead of hydrogen ion: (1) polyvinyl alcohol, (2) polyvinyl chloride, (3) nitro cellulose. B—Bonding to chemisorbed layer of water on glass surface.

approach to the oxide ion in the surface. Moser (*26*) finds little or no adhesion of polyvinyl chloride and nitrocellulose to such glass surfaces.

The energy of the dipole-ion bond, at equal distance of separation of the interacting species, usually will be greater than that of dipole-dipole interactions or hydrogen bonds, though inclusion of dispersion forces with the latter two may result in an overlapping of their ranges of energy with that of the ion-dipole type of interaction. Geometric considerations such as the size and accessibility of the dipole and the angle it makes with the surface ion can have very considerable effects on the actual energy of interaction between ions and dipoles.

Two other factors also are of great importance in actual systems of adhesives and adherends. Competition for the surface ions by dipoles of the adhesive and dipoles of the solvent, as well as those of added plasticizers, can reduce the effectiveness of the ion-dipole interaction between adhesive and adherend very greatly and give rise to weak adhesive-adherend bonds, even though these bonds might be strong in absence of solvent or plasticizer. The other factor of interest here is the interaction, between the dipoles of the polymer chain which gives rise to chain stiffness in adhesives such as cellulose nitrate, polyacrylonitrile, and polyvinyl chloride. The internal interactions may be so strong, and numerous, that the dipoles bond very weakly or not at all to surface sites (*27*).

When using adhesives containing these strong dipoles, polar plasticizers and strongly polar solvents are required and the competition for surface sites in turn can reduce the adhesion. Factors such as these, then, can be responsible for poor adhesion in systems in which the bonding would be strong if there were no complications. Bonding through dipole-dipole and dispersion force interactions is subject to many of the same anti-bonding effects.

Summarizing, the ion-dipole bond is stronger, the more ionic the surface of the adherend and the polar group of the adhesive, the closer the dipole can approach the ion up to a certain limit, and the more nearly the angle between the two is to 180°. Forces of repulsion start sharply to reduce the interaction when the dipole and ion are less than about 2.0-2.5 Angstroms apart. The surface ion is not a free ion in the adhesive-adherend system and this affects the force acting between it and a dipole.

D. Animal glue and polyesters—One of the earliest methods of making frosted glass was to form a film of animal glue or gelatin on the surface and to strip the film off when dry. In the operation, particles of glass were pulled out of the surface. That such a result can be obtained indicates that the surface-glue interaction is very strong and that the interfacial bonds are stronger than the hydrogen bonds of the protein molecule. Since probably relatively few surface bonds are formed they must be strong.

Representing the surface of the gelatin molecule by

$$^{-}OOC\text{–}R\text{–}NH_3^{+}$$

a glass surface like that in Figure 6A might be expected to enter into very strong, essentially ion-ion bonding, with $-NH_3^+$ group of the protein and and a similar type of bond could form on the surface shown in Figure 6B, with the amino group replacing the hydrogen on the surface.

A more complicated reaction involving formation of calcium proteinate and subsequent anchoring of $-NH_3^+$ groups on the

$$\begin{array}{l} | \\ -\overset{+}{Si}\text{–}\bar{O} \\ | \end{array}$$

surface would seem to be possible in the presence of the water from which the gelatin is deposited on the glass. Unreacted –NH or $-NH_2$ groups, resulting from amine hardening agents chemically linking to only one instead of two epoxy chains, may form similar strong bonds with glass surfaces. Polar –C = O and –NH groups in the surface of the protein molecule also would contribute to its adhesion to glass though the bonds would not be so strong as with the ionized groups

$$-NH_2^{+} \text{ and } -C\bar{O}O.$$

Polyesters applied to glass surfaces are not noted for strong adhesion and unless surface hydrolysis occurs to form hydroxyl and carboxyl groups, accompanied by chain cleavage, only relatively weak dipoles are available for interaction with the various glass ions shown in Figure 6. The available dipoles also are on stiff, cross-linked chains. While free hydroxyl and carboxyl groups are present prior to completion of the cure of the resins, these groups would only be expected to attach to the

About the Author . . .

J. E. RUTZLER, Jr. holds a Ph.D. in physical chemistry from Cornell University. An associate professor at Case Institute of Technology, Dr. Rutzler is present chairman of ASTM's Committee D-14 on Adhesives. He founded the Gordon Research Conference on Adhesion.

$$\begin{array}{l} | \\ -\overset{+}{Si}\text{–}\bar{O} \\ | \end{array}$$

surface structure.

Opposing such a tendency, however, is the consumption of carboxyl and very weakly ionizable hydroxyl groups in the esterification reaction that forms the cross-linked resin. Thus there seem to be left only

$$-\overset{+}{C} = \bar{O} \text{ and } \begin{array}{l} | \\ -\overset{-}{C}\text{–}\overset{+}{H} \\ | \end{array}$$

polar groups for bonding to the glass surface. The positive end of the

$$-\overset{+}{C} = \bar{O}$$

group would find difficulty in fitting close to the surface and the group dipole moment of the

$$\begin{array}{l} | \\ -\overset{-}{C}\text{–}\overset{+}{H} \\ | \end{array}$$

group is extremely small (*3*). Hence the bonding is presumed to be due to van der Waals or very weak ion-dipole forces. Thus a consistent explanation of the weak adhesion of polyesters to glass is arrived at.

It is frequently thought that introducing flexibility into the adhesive layers lying at or near the adhesive-adherend interface increases bond strength by distributing stress concentrations. While this is undoubtedly the case, another factor may enter the picture because the more flexible polymer molecules have more geometric freedom to deposit active bonding groups upon the surface. As a result, the introduction of flexibility may increase the total strength of the adhesion by providing more interactions with the surface as well as by distributing stresses.

To Be Continued . . .

The concluding portion of this article will appear in our July issue.

By W. L. ROSSIN
Research Sales, Inc.
Mahwah, N. J.

Process Improvement for
Solvent-Cut Neoprene Cements

Research Sales, Inc., Mahwah, N.J., makers of solvent-cut rubber cements, has recently cut manufacturing costs while improving its rubber cements by the use of premixed resin dispersions of magnesium oxide and zinc oxide.

The specialty operation of Research Sales requires that fully-cured, solvent-cut neoprene cements and coating be made frequently in batches of varying size for their custom trade. Milling each batch of rubber separately is costly in labor and may delay rush shipments.

For economical milling, at least four hundred pounds of elastomer compound must be compounded. Often there is compounded material left over from an order and this stock may crystallize before the next batch is made. This is particularly true of Neoprene AC or other fast-crystallizing grades.

Masterbatching is, of course, an obvious answer and the procedure was tried by us many times. However, it was felt the the masterbatches in SBR or neoprene were never uniform and that the rubber milling never gave an adequate breakdown of the oxide agglomerates. The masterbatches of zinc oxide, in particular, either in SBR or neoprene, took too long to solvate and did not give stable dispersions in our solvent. This in turn affected adversely the quality of the final product. In addition, power and milling time were expensive.

The success of our improved process depends on a highly aromatic resin called "Kenflex." This resin has good wetting properties, fully compatible with neoprene and other rubbers and, above all, with no effect on the cure rate. With this resin—a condensate of dimethyl naphthalene and formaldehyde, sold commercially as "Kenflex A," plus the milling on a three-roll mill, the average particle size of the zinc oxide is small and the percentage of agglomerates is reduced below that of the original zinc oxide powder or the neoprene millbase.

The resin dispersions of the oxides are supplied as pastes in 50-lb. pails. Similar dispersions in heavy cuttable pastes are widely used in the rubber trade for Banbury or mill mixing. However, we at Research Sales have preferred to use the softer paste in "Kenflex N" since the softer material will dissolve faster in our system. A simple formulation will illustrate:

Neoprene AC	100
Sodium Acetate	2
Antioxidant, Amine Type	1
Magnesium Oxide	4
Zinc Oxide	5
Phenolic Resin	63
Precipitated Silica	8
	183

In the new procedure, which avoids milling entirely, raw neoprene in chip form is dissolved directly in the standard horizontal rubber churn. The chips—about 1½" to 3" cubes—are more easily dispersed in toluol and methyl ethyl ketone than is the milled sheet. This shortens the solvating time and also avoids the expense of milling and then cutting up the milled sheet.

The Kenmix resin dispersions of magnesium oxide (40 per cent magnesium oxide) and Kenmix-zinc oxide (50 per cent zinc oxide) are weighed out, then dispersed directly into the neoprene-solvent mix. Since these dispersions have been previously milled for uniformity and freedom from agglomeration, they will disperse quickly and easily. NA 22 or another non-polar accelerator is added directly as the dry powder since these accelerators are soluble in the common cement solvents.

This process has several advantages in addition to cost cutting. First, the product is better since it is more uniform as well as more stable. No longer need we have the old labelling advice, "shake well before using." Second, the raw neoprene will stand longer storage before crystallizing than will the milled and compounded elastomer.

After six months storage, a typical cement, made by milling according to the formulation above, had sediment in the bottom, up to 30 per cent of the height of the sample container. In contrast, the material made with Kenmix dispersions was perfectly uniform after the same time.

When neoprene cement is made to adhere to a cellulosic material, the zinc oxide is increased to twelve parts to take up hydrogen chloride released during the cure and which might damage the fibers. This extra zinc oxide may be added to the same neoprene dispersion to modify it for the second use, without having to mill separately for each new application.

The lower cost of manufacture and the uniform improved product allowed by this dispersion method is expected to increase our production substantially.

Comparison photo of sediment formation in neoprene adhesive with milled oxides (left) and batch with pre-mixed magnesium oxide and zinc oxide resin dispersions.

Note: Kenmix and Kenflex are trademarked products of Kenrich Corp., Maspeth, N. Y.

NEWS of the

ADHESIVES WORLD

Committee D-14 Holds Spring Meeting

Symposium on Adhesives Testing Features Two-Day Session at University of Michigan

Committee D-14 on Adhesives of the American Society for Testing Materials held its Spring Meeting on April 28 and 29 at the University of Michigan, Ann Arbor, Mich. The attendance of over 60 members and guests was easily the largest in recent years and included representatives from all sections of the country.

Meetings of the Committee's 12 subcommittees were held on both days at the University's Rackham Amphitheater, and on the evening of the 28th a special symposium on "Adhesive Testing" was presented. Speakers included Dr. Joseph E. Marian, California Forest Products nology, whose topic was "Surface Properties of Wood as Related to Joint Strength," and Dr. John E. Rutzler, Jr., Case Institute of Technology, whose topic was "Surface Properties of Metal as Related to Joint Strength." Dr. Rutzler is the current chairman of the D-14 Committee.

As a result of a special session led by E. M. Chmiel, Minnesota Mining & Mfg. Co., it was decided to form a new subcommittee to work up standards on adhesives for floor tile. Chairman of the new Subcommittee XIII will be Charles W. Bayley, Jr., Borden Chemical Co. Other members include Mr. Chmiel; Ben Y. Couch, Weyerhaeuser Co.; Harry L. Rice, Rubber & Plastics Compound Co., Inc.; and C. K. Merrill Winne, Koppers Co. The subcommittee decided not to restrict itself, but will be concerned with asphalt, plastic, rubber tile, and wood block bonded to any floor surface, whether below, on or above grade.

In other business handled at the sessions, the recent ballot of the Committee on increasing the rate of test on metal-to-metal bonds in Method D1002 was approved. Further work on the revision of this test method is to be undertaken by the Western Group of Subcommittee XI on Metal Bonding. The Advisory Committee recommended that H. R. Butzlaff, A. O. Smith Corp., and D. A. George, National Bureau of Standards, be designated authors of a paper describing the round-robin tests made as a basis for this important change.

Subcommittee III on Permanence of Adhesive Bonds reported on revisions for test method D1183 on "Resistance of Adhesives for Wood to Cyclic Laboratory Aging." According to the report, a round-robin series of tests made with wood, plastic and metal adherends has shown that the procedures are applicable to adherends other than wood.

Subcommittee IV, Working Properties, prefared for submission to the Committee a method for determination of pressure-sensitive tack, and for the flow of adhesives.

At the session of Subcomittee X on Wood Adhesives, R. F. Blomquist, chairman, reported that the subcommittee is now organized into two groups, based on geographical locations and interests, for greater efficiency. Mr. Blomquist, U.S. Forest Products Laboratory, Madison, Wisc., will be chairman of the East Coast Group. J. R. Ash, Monsanto Chemical Co., Seattle, Wash., will be chairman of the West Coast Group. Both groups will have similar organizations including sections on lumber adhesives, veneer adhesives, assembly adhesives, pulp and particle board binders, and adhesives for wood to other materials.

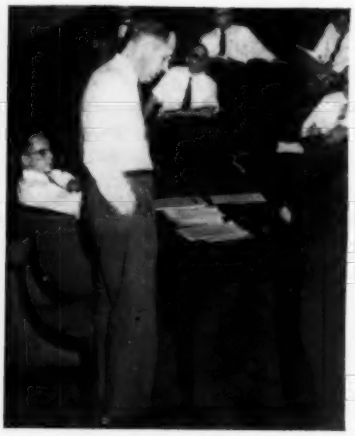
Subcommittee XI on Metal Bonding Adhesives reported that it is reviewing existing test methods and new methods are being developed for shear, creep, fatigue, impact, high and low temperature testing, weathering exposure, permanence in exposure to various media, metal surface preparation, and inspection and process control. A West Coast Task Group has been organized to consider some of the test methods. Chairman of the new group is Dr. Stephen Yurenka, Narmco Industries, Inc., San Diego, Calif.

The meeting of the D-14 Committee was concluded with a talk by Dr. Frank W. Reinhart, chief of the Plastics Section of the National Bureau of Standards. Dr. Reinhart, who is a member of the ADHESIVES AGE Editorial Advisory Board, spoke on "The Science of Adhesion."

The Fall Meeting of Committee D-14 was set for October 27 and 28, 1959. It will be held at the Case Institute of Technology, Cleveland, Ohio.

Turn the Page on the Camera Report on the D-14 Spring Meeting

Camera Report on D-14 Spring Meeting



Top Left: Dr. John E. Rutzler, Jr., chairman of the D-14 Committee, opens the meeting with some remarks on topics to be covered. Top Right: More than 60 D-14 members and guests attended the sessions held in the Rackham Amphitheater. Center Left: Frank W. Reinhart, chief of the Plastics Division of the National Bureau of Standards, offers some pointers on ASTM procedure. Center Right: D-14 members enjoy a short coffee break. F. H. Wetzel, Hercules Powder Co., in the foreground. Bottom Left: R. F. Blomquist, U.S. Forest Products Laboratory, delivers report of subcommittee on Permanance of Adhesive Bonds. Bottom Center: Dr. J. E. Marian, California Forest Products Laboratory, speaking on the surface properties of wood. Bottom Right: Harry Rice, Rubber & Plastics Compound Co., Inc., tells of the necessity for flooring adhesives standards. Seated is E. M. Chmiel, Minnesota Mining & Mfg. Co. As a result of this session, a special subcommittee on flooring adhesives was formed.

M&C Appoints Wert

Robert W. Wert has been appointed field representative for chemical distributor operations of the Minerals & Chemicals Corp. of America, Menlo Park, N.J. According to the company, Mr. Wert will provide technical assistance to its 30 chemical distributors and their customers located in the United States, Canada and Mexico. Emphasis will be placed on the application of aluminum silicate pigments and attapulgus clays used in the manufacture of adhesives, paints, plastics, inks, rubber, fertilizers and other chemical products. Mr. Wert is a graduate of Duke University where he received a B.S. degree in chemistry. He joined the company in 1944 and formerly was manager of agricultural sales.

Overseas Offices

Narmco Resins & Coatings Co., Costa Mesa, Calif., has announced the opening of overseas technical sales offices in Japan and Australia. The company produces structural adhesives and plastics for military, industrial and consumer use.

New Polymer Plant

UBS Chemical Corp., Cambridge, Mass., has announced that its new polymer plant in Lemont, Ill., is now on stream to produce polystyrene based emulsions for the floor finish industry. The plant was completed in January and will concentrate on the production of Ubatol, the trade name for a series of polymer emulsions manufactured by UBS. The company has named Roland Avery to the post of plant manager. Mr. Avery has been with UBS since 1956 and has worked primarily with the technical service and application research of polymers.

New Research Center

Robert P. Morningstar, textile chemical consultant, has announced the establishment of Morningstar Research Center, Inc., at Milford, Penna. According to Mr. Morningstar, the new company will provide consultant services in textile sizings and related chemical fields. Mr. Morningstar was the founder of the Textile Chemical Division of Morningstar-Paisley, and headed the division for more than 30 years.

3M Names Four

Minnesota Mining & Manufacturing Co., St. Paul, Minn., has announced that John B. Peters, managing director of the company's Argentine subsidiary, has been promoted to area manager, South America. The company also announced that R. S. Priebe, managing director of MM&M Australia, has been named senior managing director of its Brazilian company. P. F. Seifert was named to succeed Mr. Priebe in Australia. H. B. Kosanke has been appointed acting general export sales manager, European area, and will become managing director of the proposed Italian subsidiary.

Dr. Weschler Joins Ciba

Ciba Products Corp., Kimberton, Penna., has announced that Dr. J. R. Weschler has joined its Structural Resins Laboratory and will be in charge of customer service. Dr. Weschler has been working in sales and technical service concerning the use of epoxy resins for electrical and coating applications since 1955. He was previously with Permacel as product development engineer.

Tamms

MAGNESIUM SILICATE — For all types of Mastic Compounds. This material has (in addition to Mastic Properties) Low Oil Absorption—Excellent Slip—Good Can Stability—and batch-to-batch consistency.

SILICAS — Available in both AMORPHOUS and CRYSTALLINE types for Butyl Compounds. AMORPHOUS SILICA is creating more and more interest for all types of Mastic and Adhesive Compounds.

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June 8-10. Annual Meeting of the Engineering Institute of Canada, Royal York Hotel, Toronto, Ont.

June 8-11. American Rocket Society, El Cortez Hotel, San Diego, Calif.

June 9-12. Material Handling Institute Exposition, Public Auditorium, Cleveland, Ohio.

June 12-15. Society of Naval Architects and Marine Engineers, "T.S. Tadoussac," on the St. Lawrence Seaway.

June 14-17. Annual Convention of American Leather Chemists Association, Grand Hotel, Mackinac Island, Mich.

June 14-19. Society of Automotive Engineers, Chalfonte-Haddon Hall, Atlantic City, N.J.

June 15-19. Annual Meeting of the American Society for Engineering Education, Pittsburgh, Penna.

June 17-20. National Society of Professional Engineers and N.Y. State Society of Professional Engineers, Hotel Commodore, New York, N.Y.

June 19-20. National Hide Association, French Lick-Sheraton Hotel, French Lick, Ind.

June 21-26. American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City, N.J.

June 22-24. Annual Meeting of American Society of Refrigerating Engineers, Lake Placid Club, Lake Placid, N.Y.

June 22-27. Railways Supply Mfrs. Association, Convention Hall, Atlantic City, N.J.

July 1-19. Chicago International Fair Exposition, Navy Pier, Chicago, Ill.

July 6-10. Gordon Research Conference, Polymers, Colby Junior College, New London, N.H.

Aug. 18-21. 10th TAPPI Testing Conference, Multnomah Hotel, Portland, Ore.

Aug. 31-Sept. 4. Gordon Research Conference, Chemistry of Adhesion, New Hampton School, New Hampton, N.H.

Sept. 9-11. TAPPI Symposium on the Fundamentals of Fiber Attraction and Bonding, Institute of Paper Chemistry, Appleton, Wisc.

Sept. 10-11. ASME Wood Industries Conference, Multnomah Hotel, Portland, Ore.

Sept. 21-25. 14th Annual Instrument Automation Conference and Exhibit, International Amphitheater, Chicago, Ill.

Sept. 21-25. International CIB Congress of 1959, Rotterdam, The Netherlands.

Sept. 27-30. American Institute of Chemical Engineers, St. Paul, Minn.

Sept. 28-30. American Oil Chemists' Society, Hotel Statler, Los Angeles, Calif.

Oct. 7. Society of Plastics Engineers, Cleveland Section, Cleveland Ohio.

Oct. 18-22. The Electrochemical Society, Inc., Deshler-Hilton Hotel, Columbus, Ohio.

Oct. 20-24. 24th Paint Industries' Show, Convention Hall, Atlantic City, N.J.

Jan. 12-15. 1960. 16th Annual Technical Conference, Society of Plastics Engineers, Conrad Hilton Hotel, Chicago, Ill.

Jan. 26-27, 1960. Society of Vacuum Coaters, Technical Conference, New York, N.Y.

Feb. 2-4, 1960. 15th SPI Reinforced Plastics Division Conference, Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Ill.

New Marketing Group

Chemical Materials Department of the General Electric Co., Pittsfield, Mass., has established a new marketing organization due to increased use of Lexan polycarbonate resin. The new organization is designed to serve increased phenolic customer and market needs. E. M. Irish, Jr., has been appointed product manager for the phenolics line, and A. J. Bzdula, former Detroit sales representative, has been named field sales manager for the Chemical Materials Department, succeeding Mr. Irish. In other appointments, W. F. Christopher was named polycarbonate market development manager, while Richard J. Thompson and John B. Lidstone have been assigned to sales development positions for polycarbonate resins. E. J. Thomas, a technical service engineer in phenolic products since 1956, assumes the Detroit-Cleveland sales post.

Offers Ultrabond 801

Polytex Adhesives Corp., Wallington, N.J., has introduced Ultrabond 801, a gray, solvent-based, fluid rubber-resin cement, for difficult adhesion jobs. Said to adhere strongly on glass, wood, ceramics, leather, fabric, cork, steel, aluminum and composition materials, the product is also highly water resistant and serviceable at boiling water temperatures. It has already been used in many diverse fields. Ultrabond is applied by means of brush, spray or roller coater. In addition to its fast wet bonding properties, it may be coated and dried on continuous rolls or sheets of sponge rubber, metal, felt, paper or cloth, the company states. The dried film has no tack, but may be readily reactivated with simple solvents at the point of use.

Sonnenborn Offers Aid

L. Sonneborn Sons, Inc., New York, N.Y., has announced that research directed toward supplying specialized petroleum solvents for industry is being intensified at its Franklin, Penna., refinery. According to the company, solvents research is designed to provide industry with tailor-made solvents to meet a variety of requirements. Facilities at the refinery, including equipment for chemical treatment, have been engineered to yield solvents meeting rigid specification with regard to hydrocarbon composition, boiling range, solvency and odor characteristics.

ASTM Reviews 1958 Fields of Activities

The American Society for Testing Materials has released summaries of its 1958 activities in the fields of adhesives, structural sandwich constructions and cement as well as 50 other fields, in its January, 1959, ASTM Bulletin. In the field of adhesives, ASTM reports that the interlaboratory work of testing some 960 specimens at four rates of loading has been completed. This study was to determine the effects of rate of loading in the results obtained in the method of test for strength properties of adhesives in shear by tension loading (metal-to-metal) (D 1002).

Analysis of the results indicate that the rate effect was negligible. The climbing drum peel test that has been accepted by government agencies will be presented to the ASTM for acceptance in June. A broad spectrum of work for wood adhesives, metal-to-metal adhesives and adhesives for plastics has been initiated through three new subcommittees organized with both West and East Coast groups. Work of the wood adhesives subcommittee is under way.

Committee C-19 on Structural Sandwich Construction reports that it has approved methods relating to the measurement of creep characteristics of sandwich constructions loaded in flexure at any desired temperature. Two methods are being developed for determining the resistance to peel of the bond between metal facings and core. One of these methods involves the use of the 4 inch diameter hand or drum peel tester.

Standards Coordination

An important development in the field of cement standards during 1958 was the establishment of a plan to coordinate Federal and ASTM standards, particularly test methods. Representatives from both the Federal Government and Committee C-1 on Cement will meet together informally when the Federal standards are under discussion. Steps toward unification of standards are being taken by the working subcommittee in suggesting revisions to several ASTM standards which will lead toward requirements and procedures similar to those in Federal standards.

Similarly, government people are noting changes that are needed in Federal standards. One new tentative method accepted by Committee C-1 in 1958 is a procedure for fineness of hydraulic cement by the No. 325 sieve, a method already included in Federal specifications. The use of low-alkali cement has been more completely defined, when reactive aggregates, in revisions to the specifications for portland cement (C 150) and the specification for air-entraining portland cement (175).

The new Morningstar-Paisley polyvinyl acetate emulsions plant in Clifton, N.J.

Morningstar Plant On Stream

Morningstar-Paisley, Inc., New York, N.Y., has announced that production of polyvinyl acetate emulsions has begun at its recently completed plant in Clifton, N.J. The company reports that the output of the new plant combined with a 50 per cent increase in the PVAc production at the company's Chicago facility has doubled Morningstar-Paisley's capacity. A company spokesman stated that the additional facilities were made necessary by the increasing use of polyvinyl acetate emulsions in the adhesives and coatings compounded by Morningstar, plus their growing popularity in a wide number of fields. In addition to the production of polyvinyl acetate emulsions, the Clifton plant also includes a facility for manufacturing liquid vinyl chloride and natural and synthetic latex compounds, which went on stream late last year.

Sells Solvent Business

Union Carbide Olefins Co., a division of Union Carbide Corp., New York, N.Y., is discontinuing the sale of solvent recovery plants, but will continue selling Columbia activated carbon for recovery purposes. According to reports, Columbia activated carbon solvent recovery previously designed and supplied by Union Carbide will be manufactured and sold by Vulcan-Cincinnati, Inc. An important reason for the company's withdrawal from the sale of solvent recovery plants lies in the fact that it does not manufacture the equipment, the company states. Union Carbide plans to provide technical service for Columbia solvent recovery equipment installed previously.

Dialdehyde Starch

Abbott Laboratories, North Chicago, Ill., has begun limited production of dialdehyde starch. According to the company, dialdehyde starch is a successful binding agent in leaf tobacco and may also be suitable as a commercial leather tanning agent. Abbott reports that the starch is under study for use as a polymer former, and in adhesives and coatings. The process used by Abbott is one patented by the Government and developed at the Northern Utilization Research Branch of the U. S. Department of Agriculture in Peoria, Ill.

Sales Up 20 Per Cent

Minnesota Mining & Manufacturing Co., St. Paul, Minn., reports that its sales for the first quarter of 1959 were up about 20 per cent over the same period the previous year. Sales totaled $102,361,998 in the 1959 first quarter, compared to $85,207,-362 in 1958. Earnings for the first quarter period amounted to $13,-191,419, equal to 78¢ a share, compared with $7,899,374, or 47¢ a share for the same period in 1958.

names in the news

Herbert E. Miegel has been appointed vice-president, engineering by Reichhold Chemicals, Inc. He formerly was process manager.

Walter J. Roider, Jr., has been appointed general manager of the Borden Chemical Co's. International Department. He succeeds **Parker B. Smith** who resigned on March 31. Mr. Roider will continue as general manager of the Casein and Special Products Departments.

David C. Hawk has been appointed manager of technical service at Cary Chemicals, East Brunswick, N.J.

Roy C. Newton, vice-president of research at Swift & Co., has retired after 35 years of service with the company.

F. L. Scott has been named technical manager of the Organic Coatings Division of Metal & Thermit Corp.

Donald G. Patterson has been named manager of the newly formed Plastics Division of Reichhold Chemicals, Inc.

Lee Terhune has been promoted to assistant development manager of the Resinite Department of Borden Chemical Co., North Andover, Mass.

Judson W. Arnold has been appointed to the post of director of development for Shawinigan Resins Corp.

Thomas W. Morningstar has been named general manager of the newly formed Gum and Technical Products Department at Morningstar-Paisley, Inc.

Maynard C. Wheeler, formerly senior vice-president, has been elected president of Commercial Solvents Corp. He succeeds **Albert Woods,** who resigned in February and is now serving as a consultant.

3M Earnings Up

Minnesota Mining & Maunfacturing Co., St. Paul, Minn., has announced that its 1958 earnings amounted to $43,669,033, equal to $2.58 per share of common stock, compared with $39,446,588, or $2.34 per share, in 1957. Consolidated sales in 1958 totaled $376,293,016, compared with $370,106,838 for the previous year. According to the company both sales and earnings represent new highs. The company reports that foreign sales volume in 1958 was the highest for any year since 3M's direct entry into foreign markets eight years ago, totaling $79.9 million compared with $66 million in 1957.

Some four per cent of sales, about $16.5 million, was spent by 3M for research and related laboratory activities during 1958, and almost 25 per cent of the company's sales for the year came from products developed and marketed in the past five years. During 1958, 3M retired all of its outstanding preferred stock with $7 million received from employee stock option plans.

Mobay Develops Coating

Mobay Chemical Co., Pittsburgh, Penna., has announced the development of a new type of protective coating, based on the reaction of a specially-blocked isocyanate and an amine-bearing resin in an aqueous solution. Preliminary tests indicate a strong potential for the new system as an easy-to-apply primer coating for the automotive, appliance and industrial enamel markets. Advantages claimed for the new one-component system are a high order of chemical resistance; excellent adhesion to metals; excellent flexibility; ease of formulation and application; non-toxic properties; non-inflammability; and reduced cost.

Expands Plant

Polymer Industries, Inc., has begun work on a $500,000 expansion of its Springdale, Conn., plant According to the company, the expansion will double its research and development facilities. Construction is estimated to be completed this fall.

Portrait Of

FRANK W. REINHART

Chief of the Plastics Section of the National Bureau of Standards, in 1957 Mr. Reinhart won the U.S. Department of Commerce Meritorious Service Award for major contributions to the science and technology of plastics and adhesives. In the same year, he also won the ASTM Award of Merit in recognition of productive service of broad scope in the Society's technical work, and for outstanding contributions through research and standards covering adhesives and plastics.

One of the charter members of the ADHESIVES AGE Editorial Advisory Board, Mr. Reinhart received his Bachelor of Science degree *summa cum laude* from Juniata College, Huntingdon, Penna., and did postgraduate work at Columbia University and the University of Maryland. Because of his work in adhesives, adhesion and plastics, he was awarded an Honorary Doctor of Science degree by his alma mater in 1958.

In his work at NBS, Mr. Reinhart directs the Bureau's research, development and testing program on adhesives and plastics. He is the author and coauthor of some 30 technical papers on various aspects of these fields.

Mr. Reinhart has been extremely active in the ASTM's D-14 Committee on Adhesives. He also participates in numerous technical associations and is a member of the American Chemical Society and the Washington Academy of Sciences.

Throwaway Tent

A disposable paper tent originally designed for military use by William Moss of Ann Arbor, Mich., is being marketed by Ford automobile dealers. The tent utilizes Kimberly-Clark's newly developed paper made of a web of textile fiber which is bonded with vinyl resin adhesive between two layers of cellulosic wadding. It is fireproofed with ammonium sulfamate and made water-repellent with Metro-Atlantic's Atcordi Z, a zirconium-based emulsion. The textile fiber accounts for 5.8 per cent of the fabric weight.

Schuler To New Post

Permacel, New Brunswick, N.J., has announced the appointment of John E. Schuler as manager of its Southern Industrial Division. Mr. Schuler previously had been manager of Permacel's Eastern Electrical Division. He is a graduate of Virginia Polytechnic Institute, receiving a B.S. degree in mechanical engineering from that institution. He joined Permacel in 1944 as a sales development engineer and subsequently became product manager and field sales manager.

Reichhold Splits Stock

Reichhold Chemicals, Inc., White Plains, N.Y., has announced that its stockholders have approved an increase in the authorized stock to 10,000,000 from 3,000,000 shares, paving the way for a proposed two-for-one stock split. According to Reichhold, doubling of the outstanding common shares will bring the total to 3,092,720. Directors of the company indicated that the remaining 6,907,280 shares authorized would be available for additional financing, for distribution as dividends or otherwise for issue upon acquisition of properties and for other corporate purposes.

The company also announced the purchase of Specialty Chemicals, Inc., Austin, Texas, for an undisclosed amount of stock. The acquired company, which will be operated as the Specialty Chemicals Division of RCI, produces accelerators for polyesters. Its production will round out the firm's extensive manufacture in the polyester field, the company states. F.M. Johnson will be general manager of the new division and Howard Greer will be sales vice-president, continuing in posts they held with Specialty Chemicals, Inc.

Western Officers Named

At a recent conference in Coronado, Calif., the Pacific Coast Section of The Society of the Plastics Industry, Inc., elected its officers for the current year, and changed its name to Western Section. The Western Section's 1959 officers are: *Chairman,* John Delmonte (Furane Plastics), member of the Editorial Advisory Board of ADHESIVES AGE; *Vice-Chairman,* James Watt (Monsanto Chemical); *Secretary,* William Rhodes (Mercury Plastics); and *Treasurer,* J. A. Carmien, (New Plastic Corp.).

Record Heyden Sales

Heyden Newport Chemical Corp., New York, N.Y., reports that its first quarter sales rose 25 per cent above those for the same period of 1958 to set a high for any quarter in the company's history. Consolidated sales for the first quarter were $13,637,000, compared to $10,943,000 in the comparable quarter of 1958. Net income after taxes for the first quarter of 1959 totaled $642,000, or 27¢ a share, compared with $406,000, or 15¢ a share, for the same period in 1958.

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TAPPI Announces Bonding Symposium

The Technical Association of the Pulp and Paper Industry has announced that it will hold a symposium on the Fundamental of Fiber Attraction and Bonding on September 9-11 at the Institute of Paper Chemistry in Appleton, Wisc. This symposium is open to anyone who wishes to attend. A registration form can be obtained from TAPPI, 155 East 44th St., New York, N.Y.

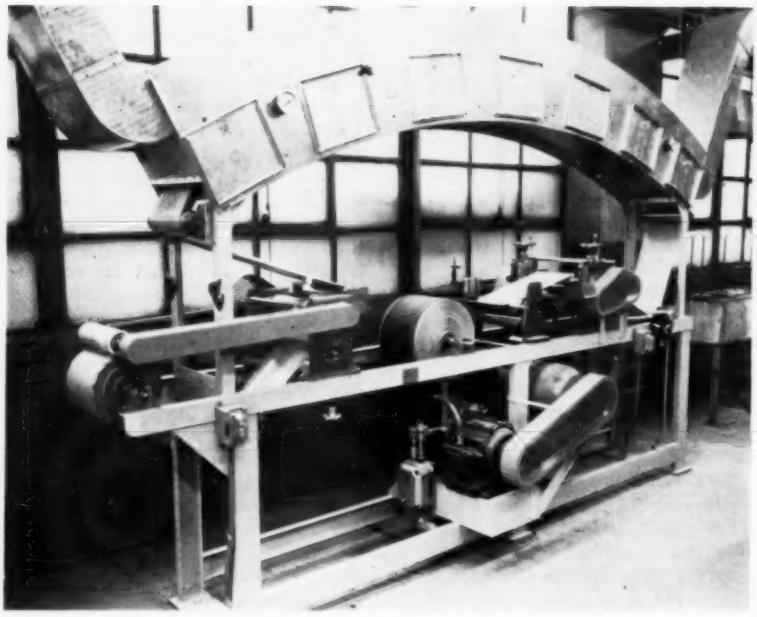
The association has announced the following tentative program. Session I on, "Principles of Adhesion" will be on Wednesday morning, September 9, under the chairmanship of Dr. Roy P. Whitney (Institute of Paper Chemistry). The papers to be given are "Fundamentals of Adhesion" by Dr. Alfred H. Nissan (Rensselaer Polytechnic) and "Structural Aspects of Bonding" by Dr. J. S. Van den Akker (Institute of Paper Chemistry).

Session II will be held Wednesday afternoon under the chairmanship of Dr. R. N. Griesheimer (Mead Corp.) and will deal with "Development of Wet Web Strength." The papers at this session will be "Fiber Agglomeration and Dewatering" by Dr. W. L. Ingmanson and S. T. Han (Institute of Paper Chemistry); "Wet Web Strength" by Prof. Dr. I. W. Brecht and Dr. R. Erfurt (Institut fur Papierfabrikation, Darmstadt, Germany); and "Some Aspects of Wet Web Behavior" by Dr. A. Robertson (Pulp and Paper Research Institute of Canada).

Session III, on "Fiber Properties Affecting Adhesion," will be held on Thursday morning, September 10, under the chairmanship of G. K. Dickerman (Consolidated Water Power and Paper). The papers presented during this session will be "Flexibility of Fibers" by Dr. S. F. Kurath (Institute of Paper Chemistry); "Drying and Shrinkage" by Dr. Harold Turkow (U.S. Forest Products Laboratory); and "Fiber Chemistry as Related to Adhesion" by New York State University College of Forestry.

Session IV, on "Development of Bonds" will be held on Thursday afternoon, under the chairmanship of Dr. R. A. A. Hentschel (DuPont). The papers presented will include "Mechanism of Bonding" by Dr. Boyd Campbell (Consultant, Montreal); "Fiber Surface Area and Bonded Area" by J. W. Swanson (Institute of Paper Chemistry); and "Bonding in Synthetic Fiber Papers" by Dr. R. A. A. Hentschel (DuPont).

Session V will be held on Friday morning, September 11, and will be on "Role of Additives in Bonding." The chairman will be Mrs. K. W. Britt (Scott Paper). The papers will consist of "Polysaccharide Adhesives" by Dr. M. L. Cushing (A. E. Staley); "Mechanism of Retention of Resin Additives" by Dr. E. F. Thode, J. W. Swanson and Dr. S. F. Kurath (Institute of Paper Chemistry); and "Electomeric Binders" by Paul J. McLaughlin (Rohm & Haas). The final session will be held on Friday afternoon and will be a panel discussion and summary, under the chairmanship of J. W. Swanson (Institute of Paper Chemistry) .



The adhesive research and development laboratories of Stein, Hall & Co., Inc., are using this paper gumming, coating and laminating machine for producing adhesives products suitable for commercial evaluation.

Stein, Hall Installs New Machine

Stein, Hall & Co., Inc., New York, N.Y., has announced an addition to its adhesive research and development facilities with the installation of a paper gumming, coating and laminating machine in its Long Island City, N.Y., laboratories. According to the company, it is expanding its program on remoistenable, heat sealable, barrier, hot melt and other specialty coatings through the use of this new equipment.

Laminating experiments will also be scheduled and a large scale program is planned for developing specialty adhesives in this field, the company states. The machine is patterned on standard commercial coating and gumming equipment and can process a 10 inch web. Actual paper converting plant conditions are duplicated and products produced are completely suitable for commercial evaluation.

Polyethylene Coating

The Plastics Division of Koppers Co., Inc., Pittsburgh, Penna., has announced the availability of a sprayable high-density polyethylene coating which can be applied to metals and glass. According to the company, the new coating demonstrates excellent continuity and has outstanding adhesion qualities on a variety of surfaces. In addition, it has superior impact resistance and flexibilty on metallic surfaces and can be applied clear or in a variety of colors, the company reports. Koppers suggests its use in industrial process equipment, tanks, drums, pipe coatings, automotive parts, appliances, marine equipment, beverage cans, etc.

Installs Equipment

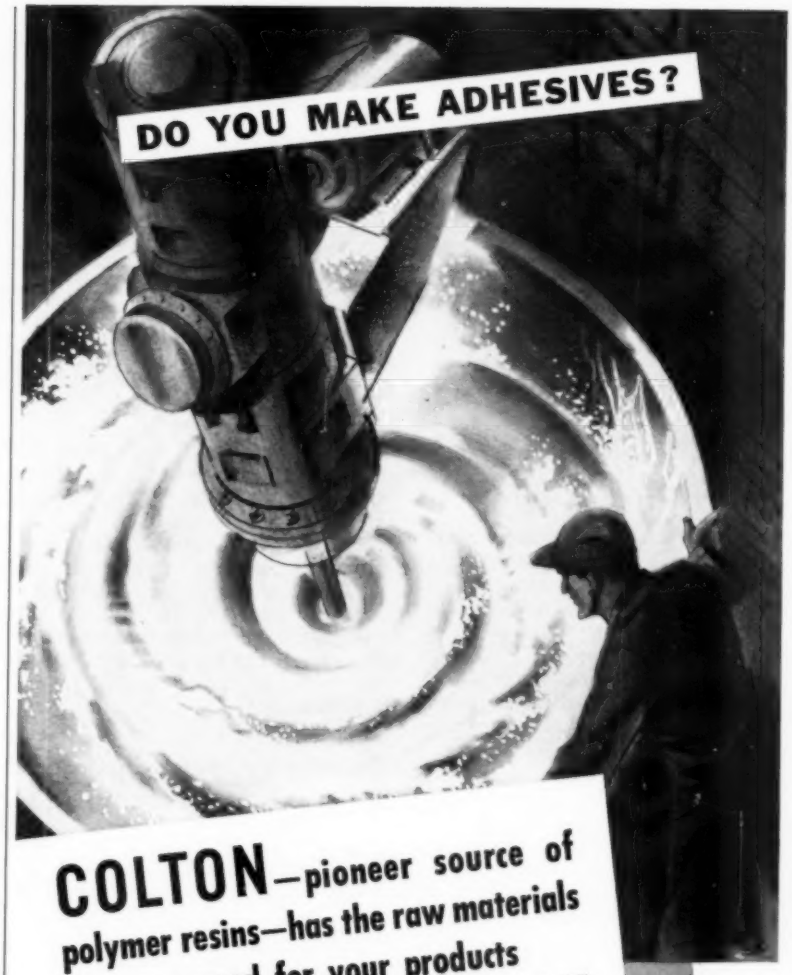
Transo Envelope Co., Chicago, Ill., has reported that between April, 1958 and April, 1959, it has invested well over $1 million in the purchase and installation of high-speed envelope manufacturing equipment. On Transo's new equipment list is a 20 ton $100,000 European import that prints, folds and gums envelopes at the rate of 24,000 per hour. Also imported is a machine designed to produce a new envelope which can be sealed without licking. The machine prints inside and outside, folds, and applies latex, all in one operation. Not including smaller printers and printing attachments, the company has made 44 equipment additions which it considers major. Most of the installations have been in Transo's Chicago plant, the remainder divided between plants in Glendale, Calif., and Jersey City, N. J.

DuPont Sales Down

E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., has announced that its 1958 sales were $1,829 million, off seven per cent from 1957. However, sales in the final three months of the year set a record high for any quarter in the company's history. According to the company, after a slow first quarter when sales were down 17 per cent from the corresponding period of 1957, they improved in each successive quarter, reaching $505 million in the fourth quarter, eight per cent ahead of the closing quarter for 1957. As compared with 1957, the physical volume of sales was about six per cent lower whereas the company's index of selling prices averaged about one per cent lower. The price index was at the lowest level since 1950 and was only five per cent above the 1947-49 average.

Technical Papers Wanted

The Society of Vacuum Coaters has announced that its next Technical Conference will be held on January 26-27, 1960, in New York City. The Society is requesting papers covering all phases of vacuum coating including equipment, materials, processes, basic theory and new applications for vacuum metallizing. Persons interested in submitting papers should send their proposal in the form of a title and abstract of approximately 100 words to John Scharnberg, Program Chairman, Bee Chemical Co., 12933 S. Stony Island Avenue, Chicago 33, Illinois.



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Murray Stempel

Heads Morningstar

Morningstar-Paisley, Inc., New York, N.Y., has announced that Murray Stempel has been named president, succeeding George J. Miller, who has been elected vice-chairman of the board of directors. Mr. Stempel, who has been associated with the Morningstar companies for the past 35 years, was formerly executive vice-president of Morningstar-Paisley. In 1931, he started an adhesives plant in Chicago, and Paisley Products, Inc. was formed as a wholly-owned subsidiary of Morningstar to operate this facility, with Mr. Stempel as executive vice-president. When Morningstar, Nicol, Inc. merged with Paisley Products in 1957, Mr. Stempel was elected executive vice-president of the combined operations.

Surface Protector

Coroshield Co., Ltd., New York, N.Y., has announced the availability, for commercial use in the United States of a new team of chemical compounds that is reported to exhibit the ultimate in anti-corrosion and surface sealing properties. Binding themselves to every kind of surface, the products form tenacious, inorganic, impervious, micro-thin films that are fire-resistant, defy chipping, peeling, flaking and abrasion, and are a defense against oxidation agents of every degree, including hydrochloric, nitric and sulfuric acid, the company states. The Coroshield protective products are Integrat, Interlex, Portalit, Portaplex, Terralin, Metalspachtel, and Korroplast. They come in liquid form and are easy to apply by spraying, brushing, dipping, filling, rolling or any other conventional lacquer applicators, the company reports.

Gummed Seminar Held

The annual Gummed Industries Association Technical Section Seminar was held at the Hotel Roosevelt in New York City on February 26. The group was addressed by Dr. Roy Whitney, Dean of Students at the University of Wisconsin and vice-president of the Paper Institute of Chemistry, who spoke on "The Institute and its Work for the Paper Industry." Of particular interest to those present were demonstrations of the Neubronner Adhesion Tester by Dean Tharp (Paper Manufacturers Co.), the Herrlinger Gummed Tape Adhesion Tester by H. E. Heise (St. Regis Paper), and the Thwing-Albert Torsion Tear Tester by Ralph Green (Thwing-Albert). Fred Holt, vice-president of the Brown-Ridge Mills, Inc., was unanimously re-elected to his second term as chairman of the Association's Technical Section, and Keith H. William of Mid-States Gummed Paper Division, Minnesota Mining & Mfg. Co., was re-elected to his second term as vice-chairman.

Named by Staley

A. E. Staley Manufacturing Co., Decatur, Ill., has appointed Leo A. Willoughby to a newly-created position of coating supervisor in its field sales organization serving the paper industry. According to the company, Mr. Willoughby will continue as sales representative in Upper Michigan, Wisconsin and Minnesota, but will aid other Staley representatives, customers and the company's paper applications research laboratory in technical service and consulting work as coating supervisor. He was a coating supervisor in the paper industry before joining Staley as a senior technical representative in 1949, and had been associated with various paper companies in Ohio, Michigan, Minnesota and Massachusetts for 30 years, most of this time in coating operations, research and supervision.

SPE Elects Officers

Society of Plastics Engineers, Inc., has elected its officers for 1959, at a recent meeting. Elected to serve during the current year are: *President,* Fred C. Sutro, Jr. (Spencer Chemical); *First Vice-President,* George W. Martin (Holyoke Plastics); *Second Vice-President,* Jules W. Lindau, III (Southern Plastics); *Secretary,* Frank W. Reynolds (IBM); and *Treasurer,* Haiman S. Nathan (Atlas Plastics).

Raymond J. Vonesh

Named By Council

Rubber & Plastic Adhesive & Sealant Manufacturers Council, Chicago, Ill., has announced the appointment of Raymond J. Vonesh as its executive secretary. Mr. Vonesh, who received a law degree from Loyola University in 1939, will retain his present duties as executive secretary of the Chicago Paint, Varnish and Lacquer Association. He is a member of the American Trade Association Executives, the Trade Association Executives Forum of Chicago and the Chicago Bar Association.

New Denver Plant

Air Reduction Sales Co., a division of Air Reduction Co., New York, N.Y., has announced the completion of a new oxygen and nitrogen plant at Denver, Col. According to reports, the new plant is the first major gas-producing installation which Air Reduction has built in the general area. Both oxygen and high purity nitrogen to be produced at the new facility will be used for a number of industrial purposes, including metal working, construction and missile development, the company states. Air Reduction also announced that William O. Brown has been placed in charge of all of its operations at Denver. Leo C. Jones, formerly superintendent of the firm's plant at Hobbs, N. Mex., has been appointed superintendent of the new facility.

Corn Products Names Two

Corn Products Co., New York, N.Y., has announced that Howard C. Harder, controller, has been named vice-president, financial, while Harold Hellman, executive assistant to the president, has been named vice-president, administration.

Nashua Exhibits

A display of new models of National sealing tape dispenser machines and Itstix gummed tapes were placed on exhibit by representatives of the Nashua Package Sealing Division of Nashua Corp., Nashua, N. H., at the National Packaging Exposition in the International Amphitheatre, Chicago, Ill., during the week of April 13 to 17. Features in the exhibit were Nashua's new National 98 Vuematic-CN and the National 52 Tu-Tayper. The Vuematic-CN is an electric-powered machine which activates, laminates and dispenses Itstix kraft or reinforced sealing tapes with a center teartape and starting tab. The machine's operation was demonstrated at the exhibit.

Use of the new tear-tape simplifies opening well-sealed cartons and containers and eliminates the use of knives, razorblades or other tools. Containers are said to remain undamaged and re-usable after opening when the new sealing tape with teartape is used. Merchandise is also protected by use of the new tape, Nashua claims. The new Tu-Tayper is a hand-operated tape dispensing machine which intermittently dispenses activated sealing or strapping tape from two different tape-rolls in various widths and lengths. This dual-purpose machine may be used to speed up the packing and shipping production line and to effect substantial economies, according to the company.

Paper Box Elections

J. N. Andrews, executive vice-president of the Ohio Boxboard Co., Rittman, Ohio, has been re-elected president of the Folding Paper Box Association. Elected to the association's executive committee were Mr. Andrews; William H. Walters, (U.S. Printing & Lithograph); W. J. Alford III (Alford Cartons); Arthur N. Morris (Newth-Morris Box); Leo H. Scheonhofen (Container Corp. of America); D. A. Forsberg (Forsberg Paper Box); and Noble Andre (Andre Paper Box). Ten directors-at-large were also elected by the association. They were A. W. Buchanan (F. N. Burt), E. B. Wall (Federal Paper Board); T. C. Nevins Jr. (Nevins Co.); Byron H. Lengsfield (Lengsfield Bros.); Herbert C. Bernard (Shuttleworth Carton); E. J. Bonville (Robertson Paper Box); Ralph Schnitzer (Magnolia Carton); Charles Ruble (Standard Paper Box); R. F. Burroughs (Trenton Folding Box); and D. A. Forsberg (Forsberg Paper Box).

No. 5 of a Series

GRIPPING STORIES

from the files of Angier Adhesives

The Case of the COSTLY CONTACT

Acme had a problem. Their new line of sandwich panels was so popular they couldn't make them fast enough. So they turned to automation. The honeycomb cores were conveyed past automatic adhesive spray guns – through drying lamps and on to "Assembly" where the faces were contact-bonded to the body of the panel.

Then Acme discovered another problem. Their adhesive was being deposited unevenly and they were getting surprisingly poor mileage from their new installation.

Acme called in an Angier man. He showed them how a specially-formulated Angier contact cement would spray smoothly and uniformly, even at maximum line speeds, and with no heavy edges or excessive overspray.

In addition to a full line of contact cements and other adhesives, Angier offers unequalled application know-how. This vast fund of practical knowledge has been gained by the service engineers of Interchemical's Finishes Division in their daily experience with some of the largest industrial lacquer and enamel users. For *real* economy in adhesives, call in an Angier man *first*.

Call or write today for more information on Angier's line of Contact Cements.

ANGIER ADHESIVES

INTERCHEMICAL CORPORATION

Finishes Division

120 Potter St., Cambridge 42, Mass.

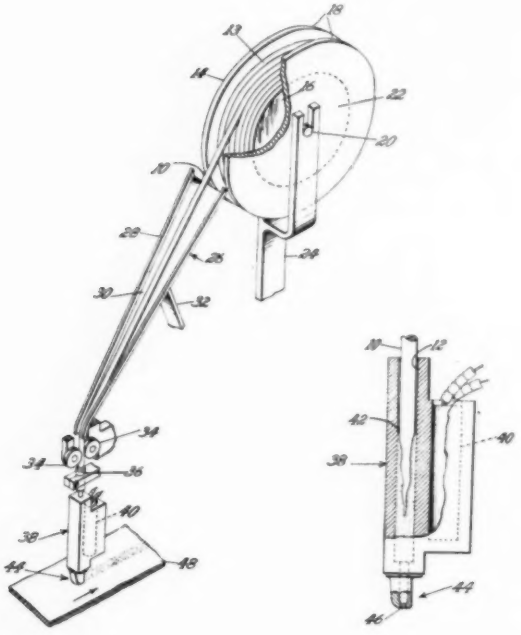
Midwestern Plant: HUNTINGTON, IND.

patent review

By MELVIN NORD

Thermoplastic Rod Adhesive

U.S. Patent 2,867,592, issued January 6, 1959 to Thomas C. Morris and Adolph M. Chaplick, assigned to B. B. Chemical Co., provides a thermoplastic rod adhesive for direct through feed dispensing.



As shown in the schematics, the thermoplastic adhesive rod (10) is an elongated self-supporting body of solid, thermoplastic adhesive having a uniform cross-section complementary to the cross-section of the entrance to the heated softening and dispensing passageway (12). The solid self-supporting rod (10) is shown coiled on a spool (14) from which it is fed to the melting and dispensing passageway (12). The adhesive rod (10), after it is uncoiled from the spool, passes through a trough (26) having side walls (28) and a bottom wall (30) supported by a post (32) and into the bite of toothed or notched feed rolls (34) which firmly grip it for applying axial pressure to the rod. From the feed roll (34) the rod (10) passes through a guide bushing (36) and into the entry end of the passageway (12) in the heating and applying member.

As shown in the schematic at right, the passageway (12) consists of a body portion (38) in one side of which is a heating element (40) to supply heat through the body portion (38) to the passageway (12). The adhesive rod (10) fills the entrance of the passageway (12), any slight gap between the rod and the walls of the passageway being sealed by softened or molten material (42). When moved forward the rod bears uniformly against the full cross-section of adhesive whether incompletely or wholly in fluid form in the forward portions of the passageway. The uniform bearing of the rod against the entire cross-section of adhesive in the passageway insures orderly progress of adhesive through the passageway which constitutes an important advantage of direct through feed adhesive dispensing.

The effective seal between the solid rod and the walls of the passageway creates a relation between them so that as the rod (10) moves into the passageway (12) an equivalent volume of heat-softened adhesive leaves the dispensing end (44) of the passageway through an opening (46) and is spread on a work piece (48) moving beneath it.

Glyoxylated Starch Compounds

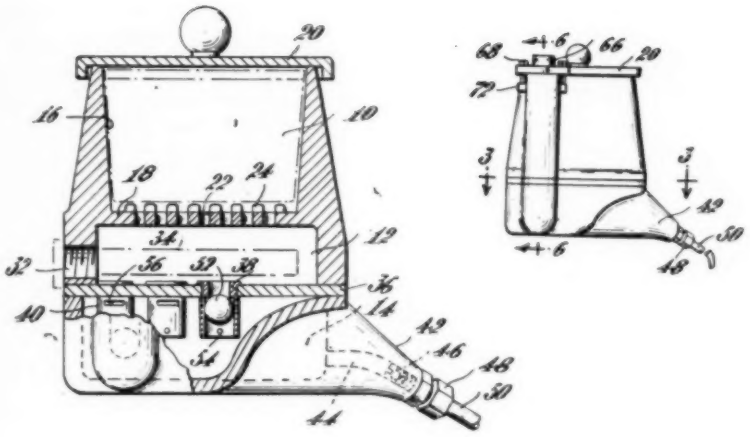
U.S. Patent 2,867,615, issued January 6, 1959 to Rene L. Lehmann and Louis Gandon, assigned to Bozel-Maletra, Societe Industrielle de Produits Chimiques, describes a process for the preparation of glyoxylated compounds of starch. These adhesives are stable and can be preserved in the form of dispersions in water, but when the water is evaporated (i.e., upon drying), give a film which is practically insoluble in water.

It has been found that the reaction of glyoxal on a starchy material forms, in the presence of water, a molecular aggregate which is insoluble in water. It is believed that the glyoxal acts on the molecules of starch as a bridge-forming agent which results, at the moment of the bursting of the grain of starch, in an insoluble aggregate formed by reticulate molecules. By continuing the heating, this starch-glyoxal gel is converted into adhesive, since the molecules become shorter and in consequence are dispersible in water. During the concentration of the adhesives by evaporation of water, the reticulation of the molecules continues and becomes more intense. Thus, the molecules are very reticulated and are practically insoluble in water.

Adhesive Dispenser

U.S. Patent 2,868,420, issued January 13, 1959 to Thomas A. Weisz, assigned to Jacob S. Kamborian, describes a container for melting and dispensing adhesive, for example, for supplying liquid thermoplastic adhesive to the applicator nozzle of a shoe or panel lasting machine or the like.

The schematic diagrams show the container, having top, intermediate, and bottom chambers (10, 12, and



14). A cover (20) is placed over the open top (10). The bottom of the top chamber contains ports (22). A solid block of thermoplastic adhesive is placed in the top chamber during operation. Heating elements may be embedded in the walls of the chambers (12 and 14) to melt the adhesive, which then flows through the ports (22) into the intermediate chamber (12) where it is kept melted, free from the oxidizing effect of air.

The bottom wall of the intermediate chamber contains ports (38), in each of which there is a check valve, consisting of a ball (52) normally resting on a pin (54), but which can be lifted by an increase in air pressure within the bottom chamber (14), to close the valve. The bottom chamber is a closed pressure chamber, containing a check valve (46), normally held closed by a spring so as to prevent escape of adhesive from the chamber.

A vertical passage (72) extends through one wall of the container, with an opening entering into each chamber. A cap (66) seals the top of the passage (72), and contains an air valve to supply air pressure to the top of the passage.

Normally the liquid adhesive stands in the vertical passage at the same level as the adhesive in the chamber (10) and the air has contact with only the small area of liquid adhesive at the top of the passage. When the air valve is tripped to admit air pressure to the upper end of the standing column of adhesive, the latter is forced downward, thereby increasing the pressure within the chamber (14) which closes the ball valves (52), opens the valve (46) and forces adhesive through the pipe to its place of delivery.

Starch Esters

U.S. Patent 2,868,780, issued January 13, 1959 to William H. Minkema, assigned to Corn Products Refining Co., describes a process for the preparation of starch esters from starch and ammonium salts of nonvolatile, organic acids, in which degradation of the starch is minimized.

Bonding Rubber

U.S. Patent 2,837,458, issued June 3, 1958 to Elmer W. Coleman, Jr., and assigned to Lord Manufacturing Co., describes a method of bonding a body of rubber (either natural rubber or an unsaturated synthetic rubber) to a non-metal substrate.

Between the rubber and non-metal substrate, an adhesive layer is interposed which consists of a mixture of an organic isocyanate and a dithiocarbamic acid derivative (either a thiuram sulfide or a selenium dithiocarbamate).

Tall Oil Rosin Sizes

U.S. Patent 2,866,782, issued December 30, 1958 to Spencer H. Watkins, assigned to Hercules Powder Co., describes a method of making tall oil rosin sizes stabilized against crystallization.

It has been found that crystallization is inhibited in paste tall oil rosin sizes by the inclusion of 2 to 20% by weight, based on the weight of rosin, of a rosin acid dimer or a mixture of rosin acid dimers.

Other Patents of Interest

Subject	Inventor or Assignee	Patent No.	Date
Silicone rubber adhesive	Wacker-Chemie G.m.b.H.	2,860,083	11/11/58
Production of urea formaldehyde core binder resins	Cities Service Research & Development Co.	2,861,980	11/25/58
Glue applying means	Melvin H. Sidebotham, Sr., et al	2,862,471	12/2/58
Quick-breaking bituminous emulsions having increased adhesion to mineral aggregate	California Research Corp.	2,862,831	12/2/58
Tape dispenser	Federal Tool Corp.	2,864,446	12/16/58
Tape dispensing device	Daniel M. Ganz	2,864,496	12/16/58
Stabilized paste rosin size	Hercules Powder Co.	2,864,716	12/16/58
Dust catching adhesive for gas filter	Research Products Corp.	2,865,466	12/23/58
Tape-dispensing mechanism	Derby Sealers, Inc.	2,866,502	12/30/58
Adhesive composition containing maleic anhydride copolymer	Johnson & Johnson	2,866,771-2, 2,866,775	12/30/58 12/30/58

Copies of any patents, including those described here, are available from the Commissioner of Patents, Washington 25, D. C., for 25 cents each. Do not send stamps.

new equipment

Laboratory Adhesives Tester

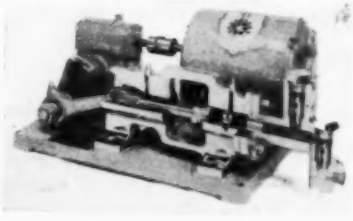
The T-A-C Tester is designed to predict in the laboratory the production performance of water and solvent-based adhesives and rewettable adhesives, such as gummed tape, by putting the adhesives and adherends under simulated production-use conditions. The tester works on the principle of bonding two adherend surfaces by an adhesive and measuring the strength of the bond by its resistance to shear or peel forces either on a curved or flat surface. Variables of bonding pressure, adhesives film thickness, open time, and closed time are all controlled, making it possible to decide on the best adhesive, the optimum film thickness, best bonding pressure and optimum open and closed time. *Thwing-Albert Instrument Co.* E-82

Viscometer

The Visco/amylo/Graph is the tradename for a new, improved model of a viscometer which has been on the market for 20 years under the name of Amylograph. The new model is the same basic design, but has five factory-installed accessories: solenoid controlled cooling coil, zero suppression attachment, interchangeable sensitivity cartridges, water-cooled stainless steel sample bowl cover and stepless variable speed control. These are in addition to three features of the old model: suspended stirrer sensing element, 100% linear torque spring and bronze bottom stainless steel sample bowl. The instrument is useful for measuring the viscosities of starch and other adhesive solutions. *C. W. Brabender Instruments, Inc.* E-83

Proportioning Pumps

High pressure, low capacity, variable volume, reciprocating plunger pumps feed as little as 1.5 gph to as much as 108 gph of corrosive or non-corrosive liquids into processes where extreme accuracy and long pump life are requirements. Packaged chemical feed units incorporating these pumps with tanks ranging from 50 to 250 gallons capacity are also available. The pumps are said to normally handle pressures to 625 psi and, with special construction, pressures to several thousand psi. They are available in various steels and with ceramic plungers when corrosive liquids are metered. Accuracy is maintained through double suction and double discharge ball checks and seats which have long life because of their design. Manual and automatic adjustment of the stroke can be made from 0 to full stroke while the pump is in operation. *Walter H. Eagan Co.* E-84

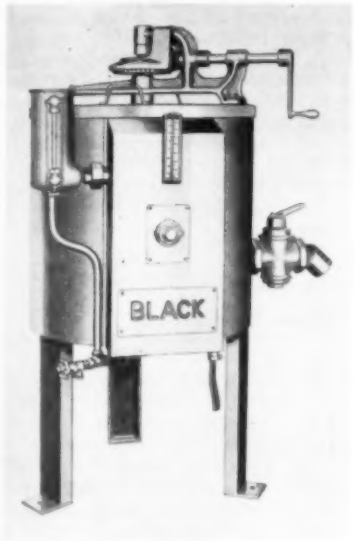


Continuous Steam Cooker

The Nemo Jet Cooker, a continuous steam cooker developed originally for preparing textile sizing mixtures, is designed to automatically maintain constant levels in size boxes. It is also applicable wherever steam is used for cooking or breaking down materials. Accurate temperature controls and adjustable production rates are said to eliminate the need for cooking and storage kettles in most applications. Among claims made for the cooker are improved freshness and consistency of prepared materials, low evaporation, reduced waste, controlled production rates, and savings on steam and raw materials. The standard unit produces from 4 to 5 gallons per minute, through cookers with larger capacities can be supplied on order. *Cocker Machine & Foundry Co.* E-85

Glue Heaters

A series of glue heaters, designated No. 700, offers units in a full range of sizes from 2½ to 125 gallons. The manufacturer states that every desirable feature for the safe, rapid and economical preparation of hot animal



glues has been incorporated into the machines, which are of the water jacketed type. The use of a liquid heating medium permits the rapid but controlled transfer of heat to the glue without danger of localized overheating. The series offers units for all types of heat, that is, steam, gas or electricity. Heavy construction provides a heater of great durability which will outlast several sheet metal heaters, according to the producer. Use of double insulation is said to result in substantial economy, the glue being prepared in less time and at less expense. The heaters are furnished with automatic thermostats as recommended optional equipment. Other features include built-in temperature indicators, safety valves, effective agitators and provision for expansion. *Black Brothers Co., Inc.* **E-86**

Paper Tester

The Minden paper tester is a mechanical instrument for determining the comparative bursting strength of paper, which is indicated on a dial in pounds per square inch, or in kilograms per square centimeter. The paper is inserted into the clamp and secured by turning a knurled disc. The handle is then rotated which increases the pressure on the paper within the clamp. As the handle is turned, this pressure is indicated on the dial until the breaking point of

the paper has been reached. The hand remains stationary and the bursting strength is read on the dial. The tester is made in two graduations, 0 to 20 pounds for testing tissue and other very light paper, and 1 to 140 pounds for testing other classes of paper. *Minden Paper Gauge Co., Inc.* **E-87**

Spray Gun

A lightweight, finely balanced, heavy-duty spray gun, recommended for adhesives and other industrial applications, is designated type P-JGA. The gun is said to offer extremely

large capacity and precision adjustments for finest quality work. Features of the instrument are: uniform spray patterns, easy handling, reinforced trigger, cartridge type air valve, forged aluminum body and convenient controls. Net weight of the gun is 1⅜ pound. A nozzle guide for selection of nozzles is offered by the manufacturer. *DeVilbiss Co.* **E-88**

Applicator Power Source

The Porta-Power-Pak is a self-contained unit that provides positive power for Semco 250 Series sealant guns. The unit consists of a five pound high pressure CO_2 tank with a pressure regulator and a pressure

indicator. A quick disconnect is supplied for easy attachment of an air line from the sealant gun. The unit is mounted on a leather harness, with which it is strapped to the body. The applicator eliminates the problem of expensive air outlets at the job location, as well as long air hoses and compressors. The unit weighs less than nine pounds, yet provides power to empty over 75 six-ounce cartridges. On the job replacement of the cylinder takes less than five minutes. Each cylinder can be recharged at any fire extinguisher agency or welding supply unit. *Semco Sales & Service, Inc.* **E-89**

FOR MORE INFORMATION on the new equipment items described here, use the Reader's Service Card elsewhere in this issue.

book reviews

1958 Book of ASTM Standards—Part 6: Wood, Paper, Adhesives, Shipping Containers, Cellulose, Leather. ***Published by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Penna. 6 x 9¼ in. 1040 pp. $10.00.***

The book of ASTM standards is a triennial publication with supplements issued in intervening years. It contains the formally adopted ASTM Standards and Tentative Specifications, Methods of Test, and Definitions. The 1958 edition comprises over 13,500 pages, and has been issued in ten parts. Part 6 contains the specifications and methods of test for adhesives and other materials. Supplements will be issued to each part in 1959 and 1960.

The section on adhesives in Part 6 contains approximately 175 pages. In addition, several specifications pertaining to adhesives, as for example, one on the adhesiveness of gummed tape in the section on paper, are located in other parts of the book. The main adhesives section contains a specification for adhesives for automatic machine labeling of glass bottles; 37 descriptions of methods of test of adhesives; and presentations of recommended practices for determining the effect of artificial and natural light on the permanence of adhesives, for maintaining constant relative humidity by means of aqueous solutions, and strength development of adhesive bonds. The section closes with a list of definitions of terms relating to adhesives.

Toward the end of the book there are sections of definitions relating to methods of mechanical testing, and to conditioning and weathering procedures. Much of this material is also pertinent to adhesives, and to the adhesives section.

The physical layout of the book meets all the requisites which one demands of such an encyclopedic volume. The standards are assembled in a sequence determined by the specific materials or products to which they apply. The type is clear, the paper of good quality, and the diagrams, illustrations and tables readily legible. The table of contents is presented in two parts—one a list of the standards classified according to the materials covered, the other, printed on colored stock, a list of the standards in numeric sequence of their serial designations. A subject index of the standards and tentatives in the volume appears at the back.

The Society has maintained the standard of editorial craftsmanship and thoroughness which it has achieved in similar volumes in the past. It is to be congratulated on the continuing high quality of its endeavors.

Quality Control in Action: Tools, Techniques, and Administrative Guides. ***(Management Report No. 9). Published by American Management Association, Inc., 1515 Broadway, New York 36, N. Y. 6 x 9 in. 116 pp. $2.00 (members); $3.00 (non-members).***

Quality control has become in this day of ever-increasing materials costs and complexity in production a very real factor in the manufacturing process. In nearly every plant definite provision is made to insure quality of product, from purchasing to processing to manufacture to final examination. The papers presented in this paperbound book, originally given at a special conference on "Quality Control in Action," held by the Manufacturing Division of the AMA, are designed to present an over-all view of the problems and practices of maintaining an acceptable standard of manufactured product in industry.

The volume is divided into four parts with the following titles: Challenge to Management, Planning and Organizing the Quality Program, Tools and Techniques, and Frontier Applications. Within these sections are 13 papers by authors from industry who tell what they and their companies have learned from current practices used to maintain quality of production. Discussed in detail are top management's responsibilities and functions in quality control; how to organize a quality control program; how to design quality into the product; how to reduce the cost of control, and other subjects. The papers contain valuable information.

Fringe Benefits. ***By Francis M. Wistert. Published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y. 5 x 7½ in. 156 pp. $3.75.***

As is pointed out in the foreword to this book, using the term "fringe benefits" to describe payments other than wages to employees for their services is becoming more and more inapplicable. These payments have become so substantial that they are scarcely on the "fringe," and for many, from presidents to janitors, constitute an important segment of the total compensation.

The author of this book wisely attempts to do other than just gather information on the common forms of fringe benefits—he presents the points of view of the interested parties, that is, employers, unions, employees and beneficiaries, and discusses the social and economic impact, or lack of impact, of the more important wage supplementation schemes.

Different chapters are used to discuss such subjects as general concepts, compulsory benefits, vacations and holidays, funded pension and retirement plans, group insurance, pay for time not worked, guaranteed annual wage, supplemental unemployment benefits, other fringe benefits and economic aspects of fringe benefits. This book should prove valuable to even veterans in the field of labor-management relations.

Trade Literature

Front Seal Gum. Two laboratory reports on fast-dry and flat-seal formulations of Rapidex, a front seal gum for high-speed machining conditions, point up the production possibilities of this product. The fast-dry formulation is recommended for use on the new high-speed machines as well as conventional equipment. Where humidity is low or where additional layflatness is required on standard speed equipment, the reports recommend the flat-seal formulation. Each report is broken down into the following sections: purpose, properties, qualities and application. *Morningstar-Paisley, Inc.* **L-91**

Sealing Concrete Surfaces. A four-page illustrated brochure contains application and test data on Kure-N-Seal, a product used for curing, sealing and dustproofing newly-poured concrete surfaces in one operation. It is a blend of synthetic rubber resins in fast evaporating solvents, which produces a transparent, hard glossy film to protect the floor from traffic abrasion, water spillage, mild acids and alkalies. It is also used as a sealer to minimize staining on terrazzo, concrete and patios. *L. Sonneborn Sons, Inc.* **L-92**

Government Specifications. Chemical products recommended to comply with U.S. government specifications are listed in this 12-page guide to manufacturers working on government orders. Included are adhesives, coatings, sealers and vinyl tubings, as well as products used in making various paints. The booklet lists the products by type, gives the specification each meets and lists the company brand name of the product meeting the specification. *Borden Chemical Co.* **L-93**

Chemicals Catalog. For the convenience of the reader, this 64-page catalog is divided into separate sections devoted to surfactants, organic intermediates, acetylene derivatives, carbonyl iron powders, ethylene oxide, and numerous specialty chemicals. The section on acetylenes offers information on n-vinyl-2-pyrrolidone which is widely used as a comonomer for copolymers employed in adhesives, coatings, textile finishes, etc. A diagram shows the chemical breakdown of this valuable comonomer which is also used in glass-reinforced plastics to give superior adhesion and bond between the resin and the glass. *Antara Chemicals.* **L-94**

Adhesive Labeler. Design information and specifications on a fully automatic adhesive label dispenser are given in this flyer. An application data sheet is attached for those who would like engineering help on how this unit can be fitted into their own production line. Information given includes a detailed rundown on the operation of the dispenser which feeds single labels from a magazine roll to an impressor device. Methods are indicated for positioning the machine to provide necessary package or product clearance for the various types of fillers, weighers, wrappers, sealers and conveyors. *Avery Adhesive Label Corp.* **L-95**

Polystyrene Adhesives. A technical bulletin on the product performance of the Dylene line of polystyrenes is divided into two sections, normal and modified polystyrenes. New applications in these groups, and charts detailing typical properties, are given. Attention is given to selecting the proper adhesive for polystyrene products. A well designed and illustrated booklet with a generous supply of pertinent technical information. *Koppers Co., Inc.* **L-96**

Resin Adhesives. The Multibond line of resin in water emulsion adhesives is described in a technical brochure. Sections are devoted to general properties, emulsion properties, film properties and adhesion properties. A long description of special characteristics which make the adhesives pertinent to various industrial uses is given. General directions for applications are also presented. *Franklin Glue Co.* **L-97**

FOR MORE INFORMATION on the trade literature reviewed here, use the Reader's Service Card which appears elsewhere in this issue.

CLASSIFIED ADVERTISING

Rates: All Classifications except Positions Wanted:

Undisplayed, per inch or fraction . $20.00

Boxed, per inch or fraction $25.00

(approximately 60 words per inch)

Positions Wanted:

Set solid, no separate headings or boxes . . . . . $2.50 for 25 words or less; extra words, 10¢ each. Count 5 words for box number address.

Replies will be forwarded via ordinary mail without charge.

Note: Cash must accompany order.

POSITIONS WANTED

CREATIVE ADHESIVE CHEMIST—10 years experience in the production, formulation and technical service of starch, dextrin, vinyl, protein, V/F, elastomeric, etc., adhesives. Desires challenging position. Address Box A-114-P, ADHESIVES AGE.

ADHESIVE CHEMIST—Thoroughly experienced in dextrin, starch, casein, animal glues, latex, polyvinyl acetate emulsions, urea-formaldehyde resins and phenol-formaldehyde resins. Desires position with good future directing and/or performing adhesive or related research and manufacturing. Address Box 115-P, ADHESIVES AGE.

HELP WANTED

ADHESIVES & COATINGS SALESMAN

National rubber company needs experienced adhesives and coatings salesman with trade following who is familiar with latex, solvents, water base, resins and mastic types. Age to 50. Some travel. Compensation by salary, bonus, expense account. Fringe benefits. Fine retirement plan. Exceptional opportunity with growth products. Send resumé and compensation required in strict confidence. Address Box A-112-W, ADHESIVES AGE.

SALES—Excellent opportunity for man with degree in chemistry or chemical engineering and minimum 5 years field selling experience primarily in glue or adhesives and secondarily in heavy industrial chemicals. Position in southeast United States with growing national chemical company requires enterprising individual capable of developing new sales area. Address Box A-113-W, ADHESIVES AGE.

ADHESIVE CHEMIST

Position available to experienced man in the field of adhesive chemistry. This is new development work essential to our expanding business. The man we have in mind knows the adhesive business, is looking for a challenge and can carry real responsibility. Location Akron, Ohio. Send confidential resumé to:

L. M. Burch, Personnel Dept.
FIRESTONE TIRE & RUBBER CO.
1200 Firestone Parkway, Akron, Ohio

HELP WANTED (Continued)

ADHESIVES SALES ENGINEER position open now with a growing company already established in the adhesives industry. Knowledge of the adhesives field needed and industrial sales experience required. Good salary plus for the right man. Call or write Sales Mgr., AMERICAN LATEX PRODS. CORP., 3341 W. El Segundo Blvd., Hawthorne, Calif. OSborne 6-0141, Ext. 270.

BUSINESS OPPORTUNITIES

CUSTOM MILLING AND SOLVENT DISSOLVING to your specifications. Latest heavy duty equipment and careful laboratory control. Please write POLYTEX ADHESIVES CORPORATION, 41 Midland Ave., Wallington, New Jersey.

EQUIPMENT FOR SALE

FOR SALE—World's largest stock of Baker-Perkins sigma blade, jacketed mixers: (43) 200 gal., (4) 100 gal., (5) 50 gal., (2) 35 gal. Prices are lower than ever before! Phone or write for details. PERRY EQUIPMENT CORP., 1414 N. 6th St., Philadelphia 22, Pa.

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in passing

Honeycomb Structures

Every manufacturer of adhesives is watching the steady progress being recorded by honeycomb structures, whether they are based on aluminum, stainless steel, fibrous glass, cotton, paper or what have you. Sales of such structures have increased from a volume of about $1 million in 1950 to some $10 million in 1958. Some trade sources predict that the market could easily reach $50 million by 1965. As a matter of fact, this figure could be substantially passed if the host of research and development ideas now in the works prove workable.

According to the best estimates available, approximately 80 per cent of honeycomb structures is going into military and aircraft applications. The floor panels of Boeing's 707 are honeycombed. The Navy is using the structures liberally in lightweight landing boats. The use of honeycombs in buildings is becoming common. Rocket engines have been made of tantalum honeycomb. Used or being tested are honeycombed desk tops, banquet tables, highway signs, lightweight doors, loading platforms, supermarket shelves and prefabricated houses.

It has already been pointed out elsewhere that honeycomb structures are nothing really new; bees have been using the technique for thousands of years by instinct alone. But man is building exceptional strength into these structures. It is claimed that honeycombs are 16 times as strong as an equal weight of steel and 10 times as strong as an equal weight of aluminum. It is even possible to make an 18-foot long plank of aluminum honeycomb which weighs only 76 pounds and yet can support a quarter of a ton at its center. And, remember, this is only the beginning.

Mailing Practices

According to a recent statement by Postmaster Arthur Summerfield, dead mail is increasing by the carload. Postmen were unable to deliver 24,054,103 letters and 622,356 packages in the year ended June, 1958 because of "careless mailing practices." This was an increase over letters and parcels which wound up in the "dead" office in the previous year. Improper or illegible addressing is a chief reason why mail does not reach its destination. Another major cause is improper packaging and inferior wrapping paper. Does this explain why that favored customer failed to get the requested sample?

The Art of Thinking

When is the last time you truly took time out to think? Particularly where a new adhesives application was concerned or where the equipment required to make such an application possible was involved? Did you really think the problem through or, like Topsy, did it just grow? To those who believe that thinking is an art we highly recommend Charles Whiting's book called *Creative Thinking* (Reinhold Publishing Co., N.Y., $3.95). Whiting emphasizes the three-step process developed by the German physicist von Helmholtz, e.g., saturation, incubation, illumination. By saturation is meant the feeding of raw material—facts, data, sensations, old ideas—to the mind, consciously and unconsciously. Incubation is carried on without conscious effort. Illumination is the idea which pops into the mind during conscious problem-solving moments or when least expected. Sound complicated? Not if you think about it for a while.

Words, Words, Words

As editors, we are intrigued with words. And the advertising people constantly work overtime to see to it that we have new ones to throw in the hopper and add to the industrial vocabulary. In the past we have had terms like "Imagineering" and "Brainwashing" and "Togetherness." Now come two new terms which you will be hearing and seeing for some time to come: Autometrology and Fluidics. These have been coined by Bendix Aviation and Pfaudler Permutit, respectively. Their meaning? *Autometrology* means the science of automatic measurement; *Fluidics* means the science of fluid treating and processing. Surely the adhesives industry should be able to coin a few new terms of its own to add to this vocabulary. Anyone want to try?

Human Depreciation

Tax time is temporarily behind us at this writing, but it is not too late to comment on an idea advanced by the Liberal Party of New York State. In its national legislative recommendations the party advanced the idea that since tax laws allow for depreciation of plant and machinery, there should also be a special exemption for working people, to allow for wear and tear on the human organism. Let's see Internal Revenue work out an acceptable formula for that one!